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Identifying "resonance" frequencies for SSVEP-BCI.

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Abstract. A Brain-Computer Interface (BCI) is a device which transforms brain signals which are intentionally modulated by a user, into control commands. One type of BCI can be realized using steady-state visual evoked potentials (SSVEPs). We developed a screening procedure to select stimulus frequency yielding the best SSVEP response. To this end we designed an experiment where participants are presented an LED stimulus flickering at frequencies from 6 to 11 Hz in 0.5-Hz steps (random order). The SSVEP response is analyzed at the corresponding flicker frequency, as well at its second and third harmonic.

Keywords: EEG; Steady-State Visual Evoked Potential; Resonance; Brain-Computer Interface

1. Introduction

SSVEP are elicited by presenting repetitive visual stimuli faster than 6 Hz, and can be recorded at occipitally mounted electroencephalogram (EEG) electrodes [Regan, 1989]. These flickering stimuli typically elicit occipital oscillations at harmonics of the stimulating frequency, as well as the fundamental frequency itself [Hermann, 2001; Müller-Putz et al., 2005]. We developed a screening procedure to select stimulus frequency yielding the best SSVEP response. The idea is to stimulate at low frequencies only and to analyse the SSVEP response also at the second and third harmonic.

2. Material and Methods

2.1. Stimulation unit, subjects and EEG recording

The stimulus was delivered via a single red LED bar (1 cm x 2 cm) flickering at frequencies from 6 to 11 Hz in 0.5-Hz steps (random order), with a duty cycle of 50%. Nine healthy subjects (8 male and 1 female, aged between 20 and 32 years) participated in the experiment. Data from one subject was discarded from further analysis due to EOG and EMG artifacts. EEG was recorded by six sintered Ag/AgCl electrodes placed over the occipital part of the head. In detail, electrodes were mounted bipolarly 2.5 cm anterior and posterior to positions O1, Oz and O2 according to the international 10-20 electrode system.

2.2. Experimental paradigm

The cue-based experiment consisted of five runs containing 44 trials each and were separated by breaks to avoid fatigue. Each trial lasted 6 s. Subjects were instructed to focus on the flickering light, placed below the screen, according to the cue-based paradigm.

2.3. Data Processing

A power spectrum analysis is performed on each of the EEG channels O1, Oz and O2. The SSVEP response is analyzed at the corresponding flicker frequency, as well at its second and third harmonic. The baseline(BL)-values for DFT analysis were computed by extracting one time segment of 1s length from each reference interval (second 0.5-1.5 in the paradigm) and each trial.

The frequency components are computed by estimating the power density spectrum (4*fs-point DFT, rectangular 1s window, FFT) of the EEG signal for each activation interval (second 4-6 in the paradigm). The three spectral components around the target frequency (e.g. for 8 Hz the components 7.75, 8.0 and 8.25 Hz) are averaged. The first three harmonics for each stimulation frequency are stored for further analysis.

3. Results

In Fig. 1 percentage band power distributions for one subject is shown. A peak at 10.5 Hz can be observed.

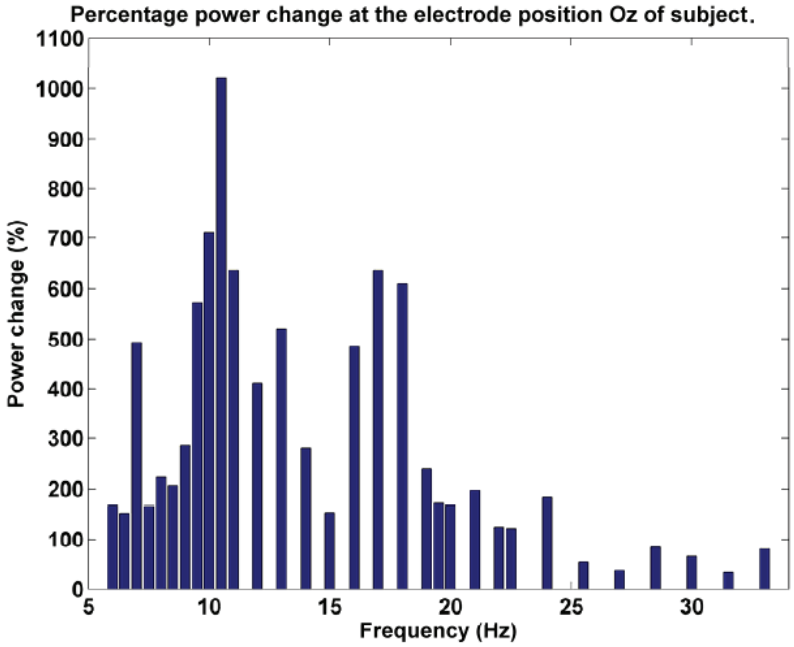

Figure 1. *Percentage band power distributions for one subject at the electrode position Oz.*

In Table 1 the frequencies exhibiting the 'resonance-like' phenomena for each subject are shown.

Table 1. *The frequencies exhibiting the 'resonance-like' phenomena for each subject.*

Subject	S1	S2	S3	S4	S5	S6	S7	S8
f 1	11	9,5	10,5	22	9,5	30	31,5	6
f 2	10,5	10	10	17	10,5	27	33	7
f 3	9,5	9	17	16	10	10	30	7,5

4. Discussion

It can be seen that the most important resonant frequency is around 10Hz (50% of cases) which is in accordance with (Regan, 1989). One subject has its resonance at lower frequencies (around 7Hz). The remaining frequencies exhibiting the 'resonance-like' phenomena are located in the low (16-22) and high (22-33) beta band.

With this method we were able to screen both the low and the medium flicker visual evoked potential (VEP) subsystems (Regan, 1989) by stimulating at only the low frequncies and by utilizing the harmonic frequency components.

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References

Herrman CS. Human EEG responses to 1-100 Hz flicker: resonance phenomena in visual cortex and their potential correlation to cognitive phenomena, in *Experimental Brain Research*, 137: 346-53, 2001.

Müller-Putz GR, Scherer R, Brauneis C, Pfurtscheller G. Steady-state visual evoked potential (SSVEP)-based communication: impact of harmonic frequency components, in *Journal of Neural Engineering*, 2: 1–8, 2005.

Müller-Putz GR, Eder E, Wriessnegger SC, Pfurtscheller G. Comparison of DFT and lock-in amplifier features and search for optimal electrode positions in SSVEP-based BCI. *Journal of Neuroscience Methods*, 168: 174–181, 2008.

Regan D. Human Brain Electrophysiology: Evoked Potentials and Evoked Magnetic Fields in Science and Medicine. Elsevier, New York, 1989.