Hybrid oddball - SSVEP BCI

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Abstract

Objectives: blablabla blalabbla Steady-State Visually Evoked Potential (SSVEP)-based BCIs.

Results: blablabla blablabla SSVEP responses.

Conclusion:

1 Introduction

2 Materials and Methods

2.1 Material

The EEG signals were recorded using a BioSemi Active Two system with 32 channels (following the 10-20 international system) at a sampling rate of 1024 Hz. Two additional electrodes were positioned on the right and left mastoids and the mean of the signals recorded at those two sites was used to reference the activity measured by the 32 EEG electrodes.

All stimulation employed MATLAB®, the stimuli were visually presented on a laptop's LCD screen (60 Hz refresh rate) and their display and timing used the *Psychophysics Toolbox Extensions* (Brainard 1997; Pelli 1997).

2.2 Experiment 1: studying the oddball ERPs

2.2.1 Experimental protocol

The aim of this first experiment was to study the effect of a flickering background on the typical Event Related Potential (ERP) response associated to an oddball paradigm. N subjects participated in the experiment (age, gender).

As shown in Fig. 1, a typical *stimulation cycle*, started with a 2000 ms cue, indicating the participant his/her target item, followed by a 1000 ms pause during which the cue disappears and all icons remained gray. The background rectangle then started to flicker and the oddball stimulation started 500 ms later. The oddball stimulation consisted of 10 *flashing sequences* during which each of the 6 icons was flashed one after another in random order for a duration randomly set between 200 and 300 ms. As usually done for oddball experiments, the participants were instructed to focus on their target symbol and count the number of time it flashes. A 1000 ms pause followed the oddball stimulation and preceded the next cue. An *experimental run* lasted approximately 4 minutes and consisted of 12 consecutive stimulation cycles, so that each of the 6 icons was cued twice (in random order).

As we aimed here at studying the effect of the flickering background on the oddball ERP response, we considered 5 experimental conditions. The first one (baseline) consisted of a run as described in the previous paragraph but in which no flickering background was displayed. The 4 other conditions differed only by the frequency of the flickering background; the frequencies used were 8.57, 10, 12 and 15 Hz, corresponding to the division of the refreshing rate of the screen by 7, 6, 5 and 4, respectively.

For each of the 5 conditions, all subjects performed 3 runs, therefore the whole experiment consisted of 15 runs of approximately 4 minutes each. The order of the run was randomized for each subject and a 5 to 10 minutes pause was set up every 5 runs.

The data collected were used to compare the shape of the oddball response (response to the flashing of the target icon) and the ERP classification accuracy (response to target *v.s.* response to non-target flasing) across conditions.

2.2.2 Data Analysis: ERP responses

2.2.3 Data Analysis: ERP classification

2.3 Experiment 2: studying the SSVEP responses

2.3.1 Experimental protocol

The aim of this second experiment was to study the effect of an oddball paradigm on the Steady-State Visually Evoked Potential (SSVEP) responses. N subjects participated in the experiment (age, gender).

The experimental run was the same as described in sec. 2.2.1. Two experimental parameters were manipulated, the first one was the stimulation frequency; the same frequencies as for the first experiment were used (8.57, 10, 12 and 15 Hz). The second experimental parameter was the presence or not of the oddball stimulation sequence. When the oddball stimulation was displayed, the participants were instructed to count the number of flashes of the target icon, while when no oddball stimulation was displayed, their task was simply to focus on their target icon.

The experiment consisted thus of 8 runs of approximately 4 minutes each. The order of the run was randomized for each subject and a 5 to 10 minutes pause was set up after the first 4 runs.

This experimental design allows a comparison of the SSVEP responses of the participants with and without an oddball stimulation superimposed on the SSVEP stimulation for a different set of SSVEP frequencies.

Brainard, D. H., 1997. The Psychophysics Toolbox. Spat. Vis. 10 (4), 433–436.

Pelli, D. G., 1997. The VideoToolbox software for visual psychophysics: transforming numbers into movies. Spat. Vis. 10 (4), 437–442.

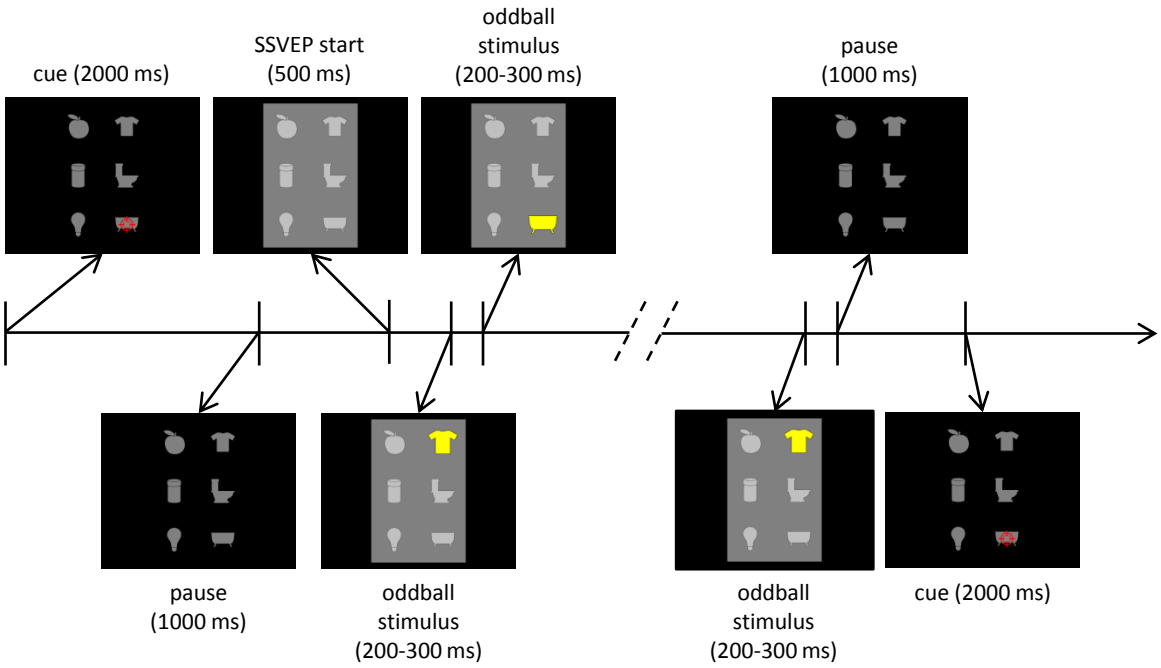

Figure 1: stimulation sequence