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Data Set Description

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Individually adapted imagery improves brain-computer interface performance in end-users with disability

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Abstract. Brain-computer interfaces (BCIs) translate oscillatory electroencephalogram (EEG) patterns into action. Different mental activities modulate spontaneous EEG rhythms in various ways. Non-stationarity and inherent variability of EEG signals, however, make reliable recognition of modulated EEG patterns challenging. Able-bodied individuals who use a BCI for the first time achieve – on average – binary classification performance of about 75%. Performance in users with central nervous system (CNS) tissue damage is typically lower. User training generally enhances reliability of EEG pattern generation and thus also robustness of pattern recognition. In this study, we investigated the impact of mental tasks on binary classification performance in BCI users with central nervous system (CNS) tissue damage such as persons with stroke or spinal cord injury (SCI). Motor imagery (MI), that is the kinesthetic imagination of movement (e.g. squeezing a rubber ball with the right hand), is the "gold standard" and mainly used to modulate EEG patterns. Based on our recent results in able-bodied users, we hypothesized that pair-wise combination of "brain-teaser" (e.g. mental subtraction and mental word association) and "dynamic imagery" (e.g. hand and feet MI) tasks significantly increases classification performance of induced EEG patterns in the selected end-user group. Within-day (how stable is the classification within a day?) and between-day (how well does a model trained on day one perform on unseen data of day two?) analysis of variability of mental task pair classification in nine individuals confirmed the hypothesis. We found that the use of the classical MI task pair hand vs. feed leads to significantly lower classification accuracy – in average up to 15% less – in most users with stroke or SCI. User-specific selection of task pairs was again essential to enhance performance. We expect that the gained evidence will significantly contribute to make imagery-based BCI technology become accessible to a larger population of users including individuals with special needs due to CNS damage.

Description

We provide EEG data recorded from nine users with disability (spinal cord injury and stroke) on two different days (sessions). Users performed, following a cue-guided experimental paradigm, five distinct mental tasks (MT). MTs include mental word association (condition WORD), mental subtraction (SUB), spatial navigation (NAV), right hand motor imagery (HAND) and feet motor imagery (FEET). Details on the experimental paradigm are summarized in Figure 1. The session for a single subject consisted of 8 runs resulting in 40 trials of each class for each day. One single experimental run consisted of 25 cues, with 5 of each mental task. Cues were presented in random order.

EEG was recorded from 30 electrode channels placed on the scalp according to the international 10-20 system. Electrode positions included channels AFz, F7, F3, Fz, F4, F8, FC3, FCz, FC4, T3, C3, Cz, C4, T4, CP3, CPz,

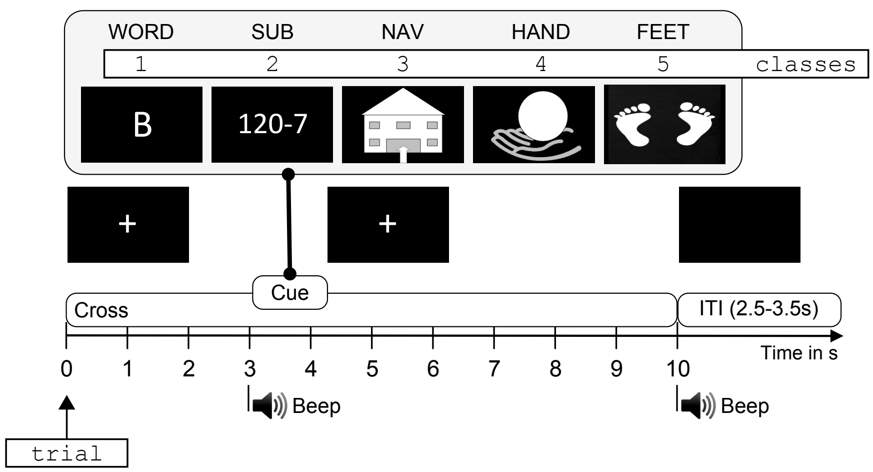

Figure 1: **Experimental paradigm.** The duration of a single imagery trials is 10 s. At t = 0 s, a cross was presented in the middle of the screen. Participants were asked to relax and fixate the cross to avoid eye movements. At t = 3 s, a beep was sounded to get the participant's attention. The cue indicating the requested imagery task, one out of five graphical symbols, was presented from t = 3 s to t = 4.25 s. At t = 10 s, a second beep was sounded and the fixation-cross disappeared, which indicated the end of the trial. A variable break (inter-trial-interval, ITI) lasting between 2.5 s and 3.5 s occurred before the start of the next trial. Participants were asked to avoid movements during the imagery period, and to move and blink during the ITI. Experimental runs began and ended with a blank screen (duration 4 s). Modified from the original publication.

CP4, P7, P5, P3, P1, Pz, P2, P4, P6, P8, PO3, PO4, O1, and O2. Reference and ground were placed at the left and right mastoid, respectively. The g.tec GAMMAsys system with g.LADYbird active electrodes and two g.USBamp biosignal amplifiers (Guger Technolgies, Graz, Austria) was used for recording. EEG was band pass filtered 0.5-100 Hz (notch filter at 50 Hz) and sampled at a rate of 256 Hz.

Data file description

Data is stored in Matlabs *.mat* file format. The filename corresponds to the user Id. Each file consists of a cell array *data* which includes two *structs*, each corresponding to one session (day). Within each *struct*, the following variables are defined:

- **X**: EEG data matrix (dimension *samples x channels*).
- **fs**: Sampling frequency in Hz (scalar).
- **trial**: Begin of trial array (length *number of trials*). Position in data points where the i^{th} trial starts. See Fig.1.
- **y**: Class label array (length *number of trials*). True class label according to the visual cue for each trial. See Fig.1. Label are assigned as follows: *1* equals *WORD*, *2* equals *SUB*, *3* equals *NAV*, *4* equals *HAND* and *5* equals *FEET*.
- **classes**: Cell array of class description (*string*).
- **session**: Session number (*scalar*).