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A Real Time EEG-Based Neurofeedback platform for Attention Training

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Introduction: A Brain Computer Interface (BCI) system as a closed-loop system can be used as a neurofeedback platform in neuro-rehabilitation programs. Here, we have developed a new attention-based neurofeedback system using noninvasive brainwaves signals. Scalp Electroencephalography (EEG) signals of a subject were collected in real-time during some minutes of sustained attention tasks in which the subject was looking at a sequence of visual stimuli pictures composited of two categories (Scene & Face). The attentional states and levels of the subject for the targeted picture will be determined by analysis of EEG data. Then, the EEG attention level classifier was fed back to our BCI platform while the same visual stimuli neurofeedback is given to the subject. It was confirmed that the transparency of a targeted picture can be controlled based on subject's attention level. The developed platform can have potential application in attention enhancement of patients with cognitive disorders.

Materials and Methods: During the experimental procedure, EEG signals were acquired wirelessly by using an Emotiv EPOC device with 14 channels and through Simulink software. The experimental tests consist of eight blocks. The first four blocks are stable blocks and the next four blocks are real-time neurofeedback blocks. Each block starts with a one second cue texture displaying the targeted picture and then, continues with 50 trials each one is one second of showing a composite stimuli picture with mixture of 50% scene (Indoor or outdoor) and 50% face (male or female). The subject was instructed to have sustained attention for the task relevant stimuli (e.g. indoor) and ignore the other stimuli (e.g. outdoor or face). The collected EEG data from stable blocks was processed in MATLAB and the features of attentional states' levels were extracted and classified. In the next four neurofeedback blocks, the output of our trained classifier was employed in real-time to determine which category was being attended by the subject and the mixture of the composite stimulus was updated for the next trial.

Results: A Simulink program has been developed to implement the neurofeedback platform. A schematic interface is shown in Figure 1. A support vector machine model was developed to classify the attention focused target using the following EEG features: relevant energies for delta, theta, alpha, beta, and gamma bands, as well as the spectral entropy. The classification was based on the 4 stable blocks. Using three blocks as training data and one block as test, an overall classification accuracy of 70% was achieved with sensitivity equal to 40% and specificity equal to 73%.

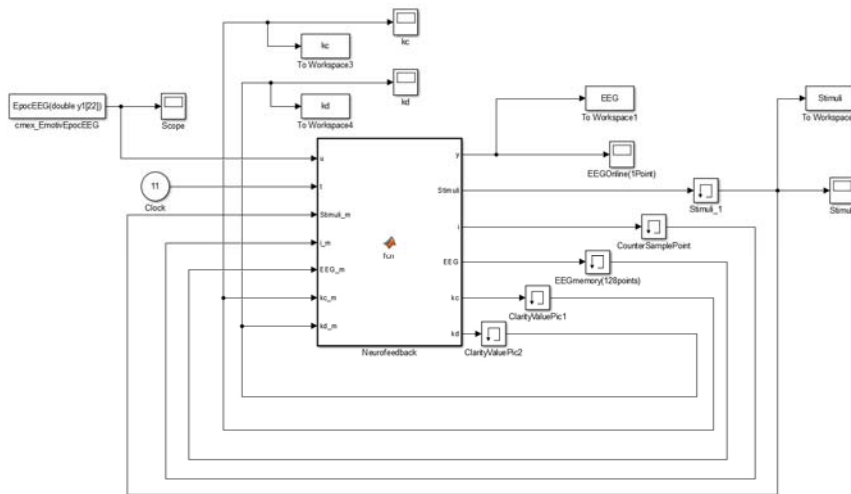


Figure 1. Schematic Simulink interface for the neurofeedback platform. EEG data is acquired using EpocEEG and fed as input to the system. EEG signal during the last second is analyzed to determine the attention level of the subject to the previous image, which determines the clarity level of the next target image. This forms a positive feedback that rewards the subject to focus his or her attention on the task.

Conclusions: A new noninvasive BCI system was developed using scalp EEG to decode the sustained attention level of a user and provide an efficient neurofeedback to the subject based on his/her level of attention. The subject reported that he is able to control the transparency of the targeted picture by paying attention to that during the experiment. Whenever, the subject loses his/her attention and the classifier confirms more attention to the task irrelevant stimulus, the mixture of picture will change to show clear picture of task irrelevant picture. In this way, the subject will be alerted to come back to his/her attending task. The current developed platform will have a potential application in enhancing the attention of patients with cognitive disorders. In the future work, we will extend the research to improve the classifier and test the platform with real patients.

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