BCI BIT RATES AND ERROR DETECTION FOR FAST-PACE MOTOR COMMANDS BASED ON SINGLE-TRIAL MULTI-CHANNEL EEG ANALYSIS

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The Leitmotiv of our BCI approach is 'let the machines learn', i.e., we aim to minimize the need for subject training while the major learning load imposed on two coupled adapting systems (human subject and computer) is to be accomplished by the machine. Here, we demonstrate detailed results from two different ERP types: 1) Our subjects take a decision that is coupled to an overlearned motor output, i.e., selfpaced typing on a computer keyboard. The spatial patterns of the slow cortical potentials preceding such voluntary movements show a negativity (Bereitschaftspotenzial) focussed over the corresponding primary motor cortex. Learning machines which are trained on spatiotemporal features of multi-channel EEG can predict the laterality of upcoming movements before EMG onset with accuracies of up to 97% in untrained subjects. One reason for choosing slow potentials as BCI-signal was that we expected this approach to work robustly also at a fast command pace. To test this hypothesis we conducted selfpaced typing experiments at different tap rates with 0.5, 1 and 2 taps per second (tps). For 8/9 subject who all were untrained for BCI the fastest tap performance (2 tps) worked efficiently, with bit rates about twice as high as in the 0.5 tps experiment. The theoretical peak bit rate, which could be attained in principle when using an optimal coding strategy, was between 6 and 10 bits per minute (bpm) for 4 subjects and even above 15 bpm for another 5 subjects. 2) One additive ('second-pass') strategy to enhance BCI classification accuracy, in particular for subjects who are facing a substantial fraction of 'first-pass' BCI classification errors, is a verification (of the first-pass classification) based on the detection of a cerebral 'error potential', as proposed by Schalk et al. In this context, we adopted the algorithmic strategy described above and introduced one small but psychologically crucial modification: because repeated false second-pass rejections of BCI trials, which had been correctly classified in the first-pass, would be detrimental, an important specification of our response verification algorithm is that the rate of false positive detections of first-pass errors should be strictly bounded. As our method detected 85% of errors in 7/8 subjects (working on a d2-test) at a predefined rate of false positives as low as 2%, this approach might provide a valuable add-on tool for improving BCI bit rates by an online EEG-based detection of first-pass classification errors.