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Classifying Emotion-Antecedent Appraisal in Brain Activity using Machine Learning Methods

Kornelia Gentsch[1], Eduardo Coutinho[21], Florian Eyben[3], Bjorn Schuller[451], Klaus Scherer[1]

Swiss Center for Affective Sciences[1], Imperial College London[2], Technische Universität München[3], University of Passau[4], Imperial College London[5]

Electroencephalographic (EEG) data offer extraordinary challenges to data analysis. EEG signals are non-stationary, characterized by trial-to-trial and subject-to-subject variability, low signal-to-noise ratio, and high-dimensionality. Classical EEG analysis uses averaging methods (typically the grand average over trials, subjects and sessions) to eliminate variability. But this approach, although valuable, is experimentally time-consuming (e.g., a minimum number of trial repetition is necessary to reduce noise), expensive, and discards possibly relevant dynamic information in the analyzed signals. In this context, machine learning methods provide particularly useful tools due to their high potential to deal with the challenges of EEG signals.

In this paper, we explore the use of Support Vector Machines (SVM) to the classification of averaged EEG data: Event-Related Potentials (ERPs). The data set consisted of ERPs related to the processing of Goal Conduciveness, Control, and Power Appraisal in the context of a gambling task. Our goal was to classify the ERP of each subject for each experimental condition ("8-class problem": win/high control/high power, win/high control/low power, win/low control/high power, win/low control/low power, loss/high control/high power, loss/high control/low power, loss/low control/high power, loss/low control/low power) and to investigate the impact on classification performance when using ERPs from single-trials and the averaged ERPs across different numbers of trials (2, 3, 4, 5, 10, 20, and all trials).

Using subject-independent cross-validation we show that all classification tests are significantly above chance level (12.5%), that the classification performance of single-trials (13.7%) is significantly worse than the classification of the average of two or more trials (ranging between 17.8% and 24.8%), and that there were no statistically significant differences between the classification performances of the ERP signals averaged across different numbers of trials. In relation to the EEG channels used, we show that using the signals from 4 channels of interest for the gambling task (Fz, FCz, Pz, and POz) we achieve a better performance than using all 64 EEG channels. Taken together these results demonstrate the usefulness of machine learning methods for the classification of ERP signals by showing preliminary evidence that with only two trials it is possible to classify EEG patterns with respect to emotion-antecedent appraisal checks. Furthermore, we also demonstrate the importance of theoretically-driven channel selection for a successful classification.