Brain-Computer Interface for the Classification of Brain Activation in Face of Ethical Decision Making

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Introduction: Non-invasive EEG is used to examine the impact of decision-making processes at the neural level with ethical dilemma scenarios as stimuli. A mixed design with two factors of interest is utilized: ethical dilemma (easy or difficult) and type of decision-making processes (individual or group).

Material, Methods and Results: The EEG data are collected at 14 channels of the sensors on the scalp: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4. Both time-domain and frequency-domain data are stratified by means of six scenarios (three difficult and three easy scenarios) for individual versus group decision-making groups. The 14 channels are imported as 14 covariates in the time-domain data. The data (theta: 4-7Hz; alpha: 8-12Hz; beta: 13-30Hz; gamma: 31-40Hz), converted using the Fast-Fourier Transform (FFT), are also imported as covariates in the frequency-domain data. Cross-correlation is calculated in order to identify functional correlated brain waves. The measurements of different waves (amplitude peaks and the time lag) are visualized and subsequently compared. Our preliminary analysis shows that the brain waves are highly cross-correlated with each other in the first 50 ms given the ethical dilemma scenarios. The results from the logistic model of FFT data show that both alpha (p-value = 0.0024) and beta (p-value = 0.0319) are statistically significant. Both theta (p-value =0.0596) and gamma (p-value = 0.077) also have p-values which are close to the significant threshold (0.05). Machine learning models are also applied for making binary classifications and predictions. For example, using the Support Vector Machine (SVM) classifier, the 2 categories (difficulty vs. easy) are classified. The prediction accuracy of the SVM model is above 80% for one subject, demonstrating a good prediction result.

Discussion & Significance: The preliminary results from three methods (cross-correlation analysis, logistic regression model of FFT data, and SVM classifier) indicate that our EEG study incorporating ethical dilemma scenarios might significantly impact on delaying subject's reaction time, observing alpha and beta waves, and possibly predicts the difficult-versus-easy ethical dilemma, respectively.

For making more long-term predictions, other deep learning approaches will be also considered such as the Recurrent Neural Network (RNN) with Long-short Term Memory (LSTM) [1] in order to avoid the long-term dependency problem in the time series data. Significant features from 14 channels as well as from different frequency ranges can be selected according to the RNN modeling framework. BCI EEG data focusing cognitive processing and emotional arousal help us more precisely understand the impact of ethical dilemma situations in individual or group decision-making.

Reference

[1] Alhagry, S, Fahmy, A. A, El-Khoribi, R. A. Emotion recognition based on EEG using LSTM recurrent neural network. International Journal of Advanced Computer Science and Applications (IJACSA), 8(10), 2017.