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EEG-Based Attention Detection through Machine Learning

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Introduction Interaction between humans and artificial intelligence (AI) still lacks the degree of engagement and entrainment that characterizes the interaction between humans. The project WithMe aims at bridging this gap by investigating in detail the processes that happen in the human brain when engaged in an activity together with another person: pursuing a common goal or simply enjoying a common activity. The brain signals that will be explored are characteristic for primarily attention, but also emotion and reward. The purpose of this research is to determine relevant electroencephalography (EEG) features indicative of attention using machine learning.

The WithMe dataset In this EEG experiment, 42 participants were involved and data was recorded at a sampling rate of 2048 Hz using the standard 64-electrode EEG 10-20 system. The data was preprocessed and re-referenced to the average of both earlobes. Bad channels were interpolated using neighboring channels, and the data was downsampled to 60 Hz. Independent component analysis was applied to the data, and any artifact components were removed by visual inspection. The preprocessing resulted in an average of less than 0.6% of epochs being rejected. Each participant was shown 30 sequences of 10 stimuli, of which 5 were targets and 5 were distractors [1]. These 30 sequences were repeated across 4 conditions, defined by the presence or absence of rhythm or auditory cues. Each stimulus generated one EEG epoch of length 1.2 seconds. This means that the final dataset, ignoring bad epochs, has dimension $(42, 1200, 64, 60)$.

Classification task The aim of the experiment was to elicit EEG P300 peaks, as cognitive attention is one of the factors that underlie the P300 peak amplitude [2]. The expected results of the experiment are a P300 peak for targets and a flat EEG signal for distractors. To effectively detect attention (or thus the P300 peak), we will develop a binary classifier to differentiate between targets and distractors. We will test and compare different model architectures, for example EEG specific classifiers like xDAWN_RG and EEGNet, but also conventional time series classifiers like (mini)rocket. To address the issue of inter-subject variability, we will compare the performance of models trained on individual participants with those trained on all participants, using metrics such as classification accuracy, ROC AUC, and F1-score. As we also have demographic and behavioral data (e.g., sex and musical education), we can explore how these variables may impact the classification performance. Finally, we will use explainable AI techniques such as saliency maps to study which part of the EEG signal was most important for the classification.

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