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EEG Data Segmentation Inducing Performance Overestimation

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Introduction: We contend that methodological flaws can lead to overestimations in accuracy for affective state estimation using EEG. One significant methodological flaw is segmentation of EEG data. To explore how EEG data segmentation affects performance, we conducted binary classification experiments using two EEG-based emotion datasets and one additional EEG dataset collected from a watermelon.

Material, Methods and Results: One of the datasets, collected at Kansas State, includes three published stimuli sets. Each stimulus was presented for 15 seconds, and participants rated it on valence, arousal, and dominance using a 5-point Self-Assessment Manikin. Thirty participants experienced 240 stimuli in total. EEG data were recorded using a 64-channel Cognionics system sampling at 500 Hz. The second dataset, collected at Virginia Commonwealth University, consists of EEG signals from 30 participants who viewed 12 one-minute video clips [1]. The third dataset, inspired by [2] was also collected at Kansas State and consists of EEG data recorded from a watermelon over a one-hour session using the same experimental setup as the first dataset. We created forty 60-second trials with a 30-second interval between consecutive trials and assigned binary random ratings for each trial.

Each trial in the first dataset originally lasted 15 seconds. To increase the sample size, we segmented each trial into n-second intervals. For example, by segmenting into 1-second trials, the total number of trials increased to 3600 (240 trials × 15 seconds). By varying n (i.e., using different trial durations), we assessed the impact of segmentation on all three datasets. The power spectral density (PSD) was averaged across four frequency bands: theta, alpha, beta, and gamma band. A binary classification with kNN was applied using the mean valence ratings as a threshold, followed by 4-fold cross-validation to calculate accuracy.

Fig 1. shows the mean classification accuracy of all participants on the valence axis for the emotion datasets and accuracy for the watermelon EEG data. The blue line represents the original accuracy, and the orange line represents accuracy by applying leave-one-trial out. From the figure, it is observed that increasing the number of trials enhances classification performance in subject-dependent analyses. Nearly 93% accuracy can be achieved with the segmentation of watermelon EEG data. However, accuracy drops to chance levels when leave-one-trial out is performed.

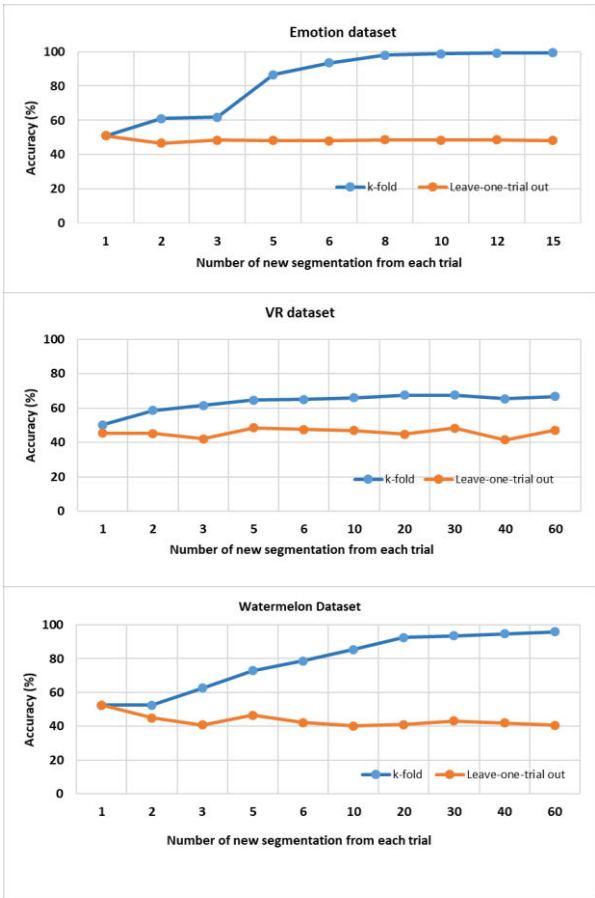

Figure 1: *Mean accuracy of all participants using different segmentation durations for three datasets (Top: Emotion dataset, Middle: VR dataset, Bottom: Watermelon dataset)*

Discussion: This study offers a preliminary analysis of EEG data segmentation's impact on affective state estimation. High classification accuracy from EEG signals of a watermelon can be achieved by simply segmenting trials, despite the absence of genuine neural responses. The overestimated accuracy across all three datasets suggests that it may be due to inherent temporal autocorrelations in EEG signals.

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