Reliability of spectral features for early ASD diagnosis in children using awake EEG

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ABSTRACT

Introduction: Autism Spectrum Disorder (ASD) is a neurological condition that has been characterized with a wide variability of severity levels, subtypes and symptoms. Early diagnosis allows clinicians and caretakers to implement early and effective interventions that can help patients in their activities of daily living. Researchers have explored potential electroencephalography (EEG) neuromarkers to assist in the prognosis and diagnosis of ASD. However, inconsistent findings due to the heterogeneity of this disorder have led to poor generalization of these neuromarkers as a diagnostic tool for ASD. Hence, this study investigates the reliability of spectral feature extracted during awake conditions in ASD children and its potential or challenges in predicting the severity of this disorder. **Materials and Methods:** Data collection was conducted at the Hospital Pakar Kanak-Kanak (HPKK) where 18 ASD children between the ages 4-16 were recruited to record their brain activity whilst in awake condition. The experiment involved EEG recording during eyes closed and eyes open as the resting condition and watching three muted videos as the activated condition. In this work, the reliability of spectral features was compared between (1) minimal and Happilee automated pre-processing pipelines, and (2) five window lengths used to estimate Welch's power spectral density. Dispersion in the spectral features across 21 scalp regions was measured using coefficient of variation and analysed using the intraclass correlation coefficient (ICC) across four 30-second epochs for each resting and activated conditions. Surface Laplacian was conducted on the clean EEG signals to reduce the effects of volume-conduction. Finally, a regression analysis was conducted to observe whether the reliability of spectral features improves the prediction of restrictive and repetitive behavioural (RRB) symptoms in ASD children. **Results:** Reliability of the spectral features in the raw EEG signals during the first two sessions (eyes-closed and eyes-open) was low for all brainwaves (ICC < 0.5) but not in the subsequent sessions (watching videos and eyes-open). This finding concurs with the remarks from lab technologists on the excessive movements exhibited by the subjects at the beginning of the EEG recording. Spectral features from the minimal pipeline had lower reliability after pre-processing (ICC < 0.75), but this improved after conducting surface Laplacian (ICC > 0.75). However, the opposite was observed from the Happilee pipeline where reliability of the spectral features extracted from surface Laplacian dropped between moderate to low ICC. Moreover, shorter window length was observed to have a slight increase in the ICC values, but still within the moderate to good reliability range. Lastly, spectral features extracted through minimal pre-processing with longer window length resulted in the strongest regression model (R2 = 0.76 and RMSE = 0.38) in predicting RRB scores. **Conclusion:** Hence, this study concludes that reliability in spectral features of ASD children may not be a good benchmark to gauge potential neuromarkers. Due to the heterogeneity of the ASD, retaining the variability of EEG signals through minimal pre-processing and the use of longer window length to extract spectral features may improve the statistical and predictive power of ASD neuromarkers.