Adaptive algorithm utilizing acceptance rate for eliminating noisy epochs in block-design functional near-infrared spectroscopy data: application to study in attention deficit/hyperactivity disorder children

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Abstract

Functional near-infrared spectroscopy (fNIRS) signals are prone to problems caused by motion artifacts and physiological noises. These noises unfortunately reduce the fNIRS sensitivity in detecting the evoked brain activation while increasing the risk of statistical error. In fNIRS measurements, the repetitive resting-stimulus cycle (so-called block-design analysis) is commonly adapted to increase the sample number. However, these blocks are often affected by noises. Therefore, we developed an adaptive algorithm to identify, reject, and select the noise-free and/or least noisy blocks in accordance with the preset acceptance rate. The main features of this algorithm are personalized evaluation for individual data and controlled rejection to maintain the sample number. Three typical noise criteria (sudden amplitude change, shifted baseline, and minimum intertrial correlation) were adopted. Depending on the quality of the dataset used, the algorithm may require some or all noise criteria with distinct parameters. Aiming for real applications in a pediatric study, we applied this algorithm to fNIRS datasets obtained from attention deficit/hyperactivity disorder (ADHD) children as had been studied previously. These datasets were divided for training and validation purposes. A validation process was done to examine the feasibility of the algorithm regardless of the types of datasets, including those obtained under sample population (ADHD or typical developing children), intervention (nonmedication and drug/placebo administration), and measurement (task paradigm) conditions. The algorithm was optimized so as to enhance reproducibility of previous inferences. The optimum algorithm design involved all criteria ordered sequentially (0.047 mM mm of amplitude change, 0.029 mM mm/s of baseline slope, and 0.6×interquartile range of outlier threshold for each criterion, respectively) and presented complete reproducibility in both training and validation datasets. Compared to the visual-based rejection as done in the previous studies, the algorithm achieved 71.8% rejection accuracy. This suggests that the algorithm has robustness and potential to substitute for visual artifact-detection.