Spatio-Frequent Linear Decoding Method for Single-Trial P300 Detection

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Background: Single-trial P300 detection has broad applications in the field of EEG based brain computer interface. Currently, researchers mainly focus on EEG signals' spatio-temporal information for single-trial P300 detection. However, studies show that information in frequency domain can also represent P300 signals' features with the advantage of resisting the latency jitter. In this study, we proposed a new spatio-frequent linear decoding (SFLD) method for the single-trial P300 detection by using the combined spatio-frequent features in EEG signals.
Methods: The SFLD method was composed of three steps. (i) The information in frequency domain was calculated by Fast Fourier Transform (FFT) for each channel's EEG signals. (ii) Multi-channel information in frequency domain was weighted by Fisher Linear Discriminator (FLD) in the spatial dimension, so as to obtain a 1-dimensional frequency feature sequence. (iii) The frequency feature sequence was weighted by logistic regression (LR) classifier in the frequency dimension, and the detection decisions were made by obtaining the final scores for the input single-trial EEG signals.
To verify the performance of the proposed method, we designed an experimental paradigm of UAV-video vehicle detection. 25 subjects (10 males and 15 females) were recruited, each participant completed a total of 200 trials (100 target trials and 100 nontarget trials). 62-channel EEG signals were collected in the experiment with a filtering range of 0.1~20 Hz. Based on the ERP alignment method, the EEG signals were segmented into target (vehicle) signals and non-target signals with 1000ms. The SFLD method was applied to detect the P300 signals after model training.
Results: Results indicated that the average AUC values of the proposed SFLD method are 0.83, which are higher than those of the existing hierarchical discriminant components analysis (HDCA) and sliding HDCA (sHDCA) methods by 0.03. Furtherly, the averaged responses in frequency domain for target and non-target signals across subjects were calculated and shown on partial electrodes. Results showed that frequency responses concentrated below 10 Hz where the differential response mainly distributed in 2~6 Hz.
Conclusions: In this study, we proposed a spatio-frequent linear decoding (SFLD) method, which integrated the information in space and frequency domain can improve the single-trial P300 detection performance. This finding emphasized the importance of information in frequency domain for single-trial P300 detection.

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Cognitive Response in Steady State Evoked Potential

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Background: Steady State Evoked Potential (SSEP) has been widely used in the clinical sensory diagnosis and brain computer interface. Through rapid repetitive stimulation, the response of SSEP mainly concentrated on primary sensory areas of the brain, and the response of cognitive component is attenuated greatly. The response frequency of SSEP varies with different sensory modality. At the rate of the 10Hz, the response of Steady State Visual Evoked Potential mainly concentrated on the occipital region. While the Steady State Auditory Evoked Potential has the main response around 40Hz. Hence, the cognitive response in SSEP has been investigated with visual and auditory stimuli in this study.
Methods: 20 subjects with the average age 22.5 years were taken participated in the experiment with three sessions. In each session, there were 10 runs with the repeated visual or auditory stimuli with the frequencies of 0.5Hz, 1Hz, 2Hz, 5Hz, 8Hz, 10Hz, 12Hz, 20Hz. Visual stimuli were delivered by white LED in session 1. Auditory stimuli were delivered with the fixed pure tone of 800Hz in session 2, and random tone from 300-1200Hz in session 3. The raw EEG data were collected by 64 channels Brainamp amplifier. Bandpass filter of 1-30Hz, re-referencing to TP9/TP10, ICA and segmentation were performed for preprocessing. Traditional average method was used for time domain analysis and Fast Fourier Transform was used for frequency domain analysis.
Results: For visual stimulation, the sensory response from the interval of 110-130ms in time domain were maintained in the visual stimulation of 0.5-8Hz. While the cognitive response from the interval of 180-240ms was gradually decreased with the increasing of the stimulation frequencies. In the frequency domain, the main sensory response was around 10Hz, while the cognitive response was in the range of theta band. For auditory stimulation, the fixed tone stimulation in session 2 did not have a clear frequency response during the experiment. By changing the fixed tune into random tune, the cognitive response would appear around theta band with the similar topography as visual stimulation.
Conclusions: Firstly, cognitive response in SSEP can be induced by saliency and novelty of the stimuli. Secondly, visual and auditory stimulation would have the similar cognitive response in frequency domain and topography. The investigation of the cognitive response in SSEP have the potential application clinical sensory diagnosis and psychological research.

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Moral Violation With and Without Physical Impurity Modulates Fairness Consideration: Evidence From EEG and ERP

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Background: In social interactions, people have a disposition to punish unfair behaviors. Moral violation is a kind of behavior that against social norms. People may respond with disgust when others violate moral standards. This may further lead to make more severe judgments about others' behavior. At the same time, individual differences in disgust sensitivity may affects this process.The present study investigates how moral violation can alter responders' fairness considerations using a system neurophysiological approach in Ultimatum game.
Methods: We recruited forty-four right-handed subjects. They played the role as responder to decide whether to accept offers from different proposers who commit neutral behavior (NN), moral transgression behavior without physical purity (WN) or moral transgression behavior with physical purity (WD). The experiment