Single-trial prediction of a Go/NoGo decision using human EEG

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Recent brain-computer interface (BCI) studies have demonstrated the feasibility of using electroencephalogram (EEG) to enhance human performance. The conventional pathway of peripheral nerves and muscles in motor control can be bypassed by a BCI; therefore, motor behaviors can be predicted more rapidly than the actual motor reaction time (RT). Recently, the prediction of a Go/NoGo decision using neuronal activities has been proposed in monkey studies. However, in human studies, the feasibility of using non-invasive methods such as EEG to predict decision making has never been reported.

We proposed to implement a single-trial prediction of a Go/NoGo decision using human EEG. Following a Go/NoGo paradigm, 15 human subjects performed in alternation an "animal" categorization task and a single-photograph recognition task. Target photographs were randomly mixed with non-target images and flashed for only 20 ms. For each target, subjects had to lift their finger from the button as quickly and accurately as possible. When non-target images appeared, subjects had to withhold their button press. For each subject, 32-channel EEG data of 10 blocks (100 trials each), were recorded and saved for offline analysis, totally resulting in 500 trials per condition.

In data preprocessing, independent component analysis (ICA) was employed to remove eye-movement and muscle artifacts. During 180 ms - 250 ms after image onset, the N2 event-related potential (ERP) component, which located over the medial frontal cortex (MFC), showed a significant difference between the Go and NoGo conditions (paired t-test, $p<10^{-5}$). Compared to the Go trials, the NoGo trials showed a larger N2 component (-9.8 uV vs. -4.5 uV), which might reflected the motor inhibition process. The intercepted ERPs from all 32 electrodes were concatenated, and then inputted to a support vector machine (SVM)-based classifier to predict the Go/NoGo decision. A 10x10-fold cross validation was used to estimate the classification performance.

The single-trial classification achieved accuracy significantly higher than the chance level using EEG data prior to RT of the Go trials (377±48 ms). The prediction accuracy was enhanced from 61.2±4.1% to 68.1±4.3%, 70.9±4.5%, and 74.4±6.3% as the length of time window increased from 200 ms to 250 ms, 300ms, and 350 ms, respectively. These results suggested that a Go/NoGo decision can be reliably predicted by single-trial EEG classification. This paradigm might have applications in fast decoding of the decision-making process to improve human performance, as well as developing a BCI system to help the disabled to communicate with their environments.