Convolutional Neural Network-Based Motor Hotspot Identification using EEG for Stroke Patients

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INTRODUCTION

- It is prerequisite to find motor hotspot before applying transcranial electrical stimulation (tES) for motor rehabilitation, which has been traditionally performed using transcranial magnetic stimulation (TMS).
- Although TMS is an ideal tool to find the motor hotspot, a cumbersome procedure involving the empirical judgment of an expert is required to find the motor hotspot.
- The objective of this study was to develop a novel deep-learning approach for identification of motor hotspot using electroencephalography for stroke patients instead of using TMS.

METHOD

Experimental Condition

- We used a conventional TMS-based method to identify the motor hotspots of both index fingers for each of 10 stroke patients with lesions in the left hemisphere (i.e., right hemiplegia) and recorded their locations in 3D coordinates.
- The 3D locations of individual motor hotspots were used as the ground truth, and they were compared with those identified by EEG to verify the feasibility of our proposed EEG-based motor hotspot identification approach.
- EEG data were measured from 32 channels according to the international 10-20 system, while each patient was performing a hand grasp task for 30 times using both hands, respectively.

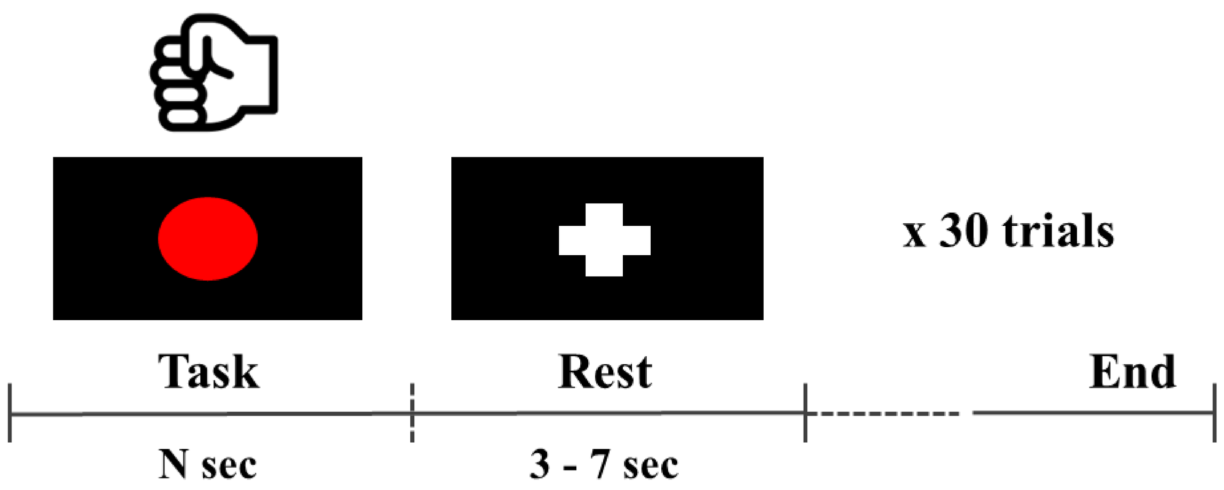

Figure 1. Experimental paradigm

Data Analysis

- After the EEG preprocessing, we epoched the EEG data between -0.5 and 0.5 sec based on an onset time when a subject pressed a button for each trial.
- Power spectral density (PSD) was estimated for each trial and each channel using the fast Fourier transform (FFT), and the PSDs of six frequency bands were calculated (delta: 1 – 4 Hz, theta: 4 – 8 Hz, alpha: 8 – 13 Hz, beta: 13 – 30 Hz, gamma: 30 – 50 Hz, and full: 1 – 50 Hz).
- The extracted features were fed into a convolutional neural network-based deep learning algorithm along with the 3D locations of the motor hotspots.
- A 5x5 fold cross-validation was performed to estimate the performance of the proposed EEG-based motor hotspot identification method using the 2D- convolutional neural network (CNN) model.
- The distance between the motor hotspots identified by TMS and EEG was calculated using Euclidean distance, which was defined as an error distance.

RESULT

- Figure 2 shows the mean error distances of motor hotspots identified by our EEG-based deep-learning approach for each frequency.
- A minimum error distance of unaffected hand (i.e., left) between the motor hotspot locations identified by TMS and the EEG data was only 0.11 ± 0.04 cm.
- Furthermore, the minimum error distance of 0.16 ± 0.10 was attained even performing the task using their affected hand.

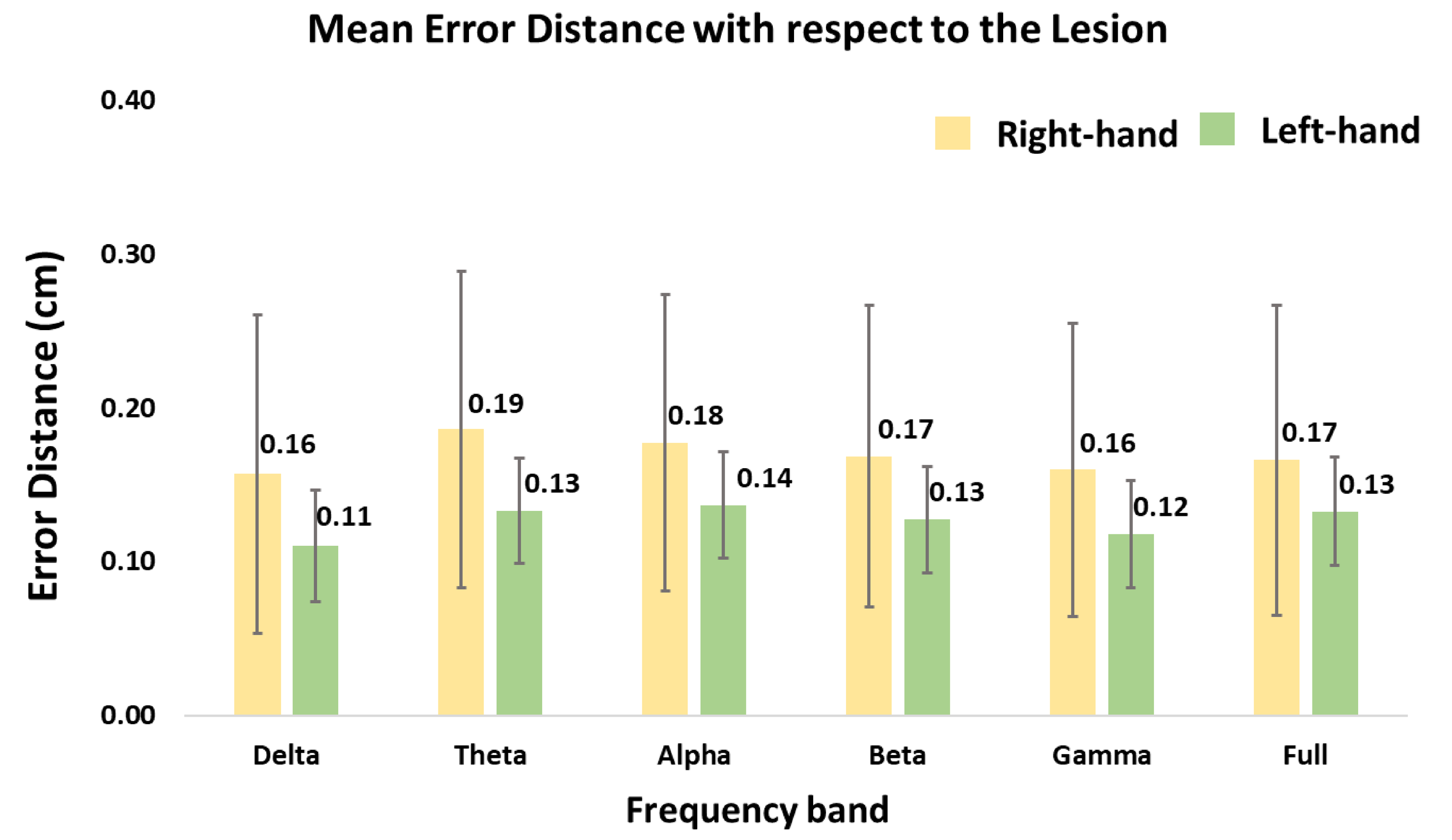

Figure 2. Mean error distances for each frequency band along with standard error.

- In figure 3, It compared the mean error distances of motor hotspot identified between stroke patient group and control group of 10 healthy subjects.

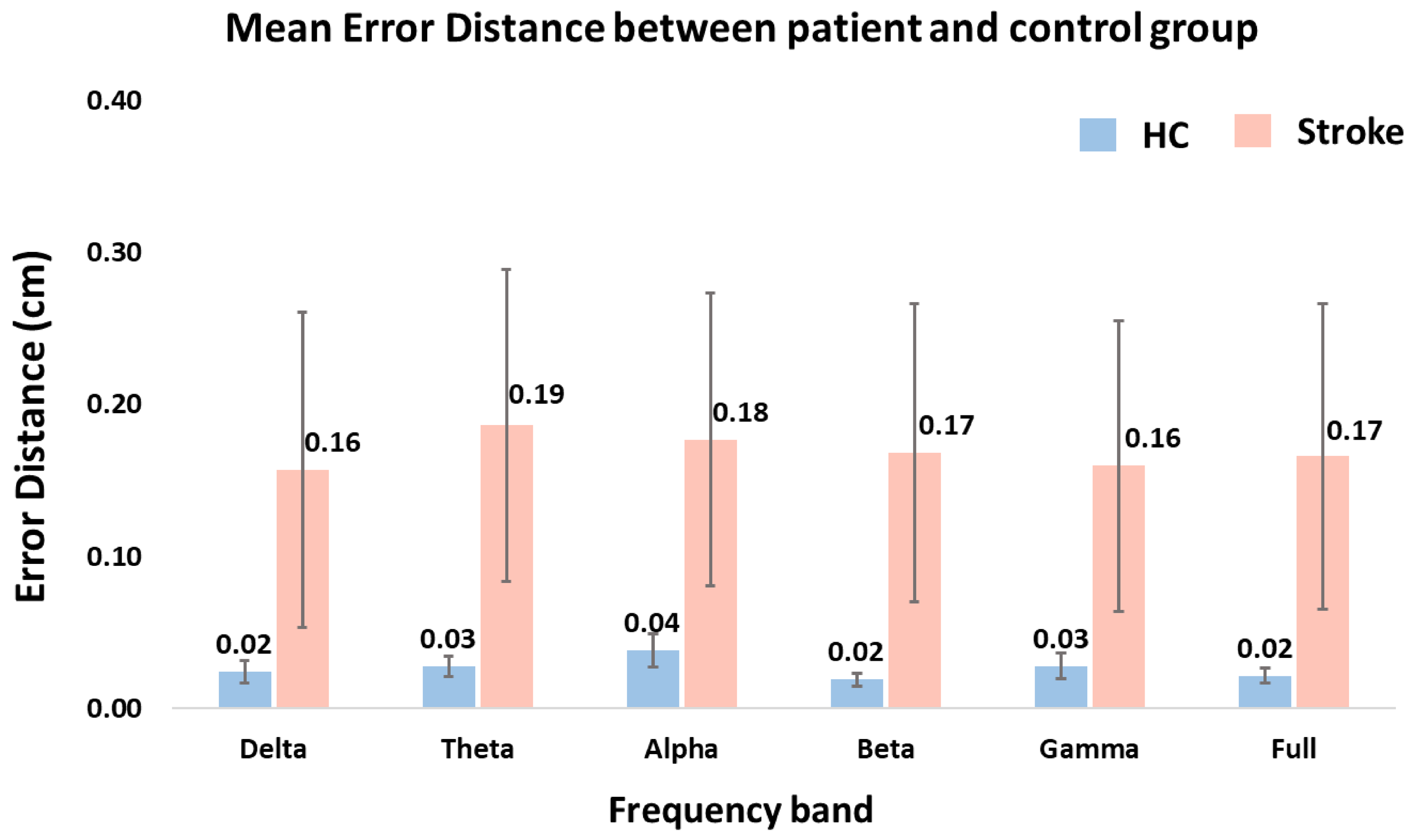

Figure 3. Mean error distances for each condition along with standard error.

CONCLUSION

- In this study, **we demonstrated the clinical feasibility of the proposed EEG-based motor hotspot identification algorithm for stroke patients.**
- Although the stroke patient group shows a slightly higher error distances for all conditions, it is expected that the motor hotspot identified by EEG features could be covered by a transcranial electrical stimulation (tES) electrode with a small error distance, as the tES electrode size is generally bigger than 1 cm.

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