Decoding the Neural Substrates of Performance Enhancement in Cognitive-Motor Dual-Task Training

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Summary

Stroke severely impairs motor and cognitive functions. This study explores neural mechanisms of Dual Task Training (DT) using EEG. Results show increased frontal activation and low-frequency EEG power during dual tasks, indicating higher cognitive demands.

Introduction

Stroke is one of the leading causes of disability worldwide, severely affecting patients' motor and cognitive functions. In recent years[1], Cognitive-Motor Dual Task Training [2]has gained attention as a comprehensive rehabilitation approach, but its underlying neural mechanisms remain poorly understood. This study aims to explore the neural activity characteristics and their abnormalities during Dual Task Training by using electroencephalography (EEG) techniques.

Methods

This study employed three types of tasks: cognitive task (CT), motor task (MT), and dual task(DT). Six stroke patients were recruited, all with the right side affected, and their EEG data were collected during various task conditions, including cognitive tasks (color and shape judgment), motor tasks (grasping a ball), and cognitive-motor dual tasks. Frequency-domain EEG indicators were extracted. Differences in feature parameters between the normal group under different task conditions were compared to explore the impact of cognitive-motor dual tasks versus general tasks on neural mechanisms.

Results and Discussion

Based on task performance(Figure 1), DT shows better performance compared to CT. DT (1.2596s, SD: 0.2549s) has a shorter reaction time than CT (1.4889s, SD: 0.2494s), and DT (0.8681, SD: 0.1287) has a higher accuracy than CT (0.7882, SD: 0.1167).

Based on the EEG topographic maps(Figure 2), in the low-frequency bands (Theta), channels in the frontal region displayed higher relative power during DT compared to the two single-task conditions (CT and MT). In contrast, in the Beta band, most channels showed a decreasing trend in relative power compared to the other two tasks. This phenomenon may reflect the enhanced low-frequency brain activity that supports higher cognitive demands during dual-task conditions, which contributes to better task performance in DT. Meanwhile, the reduced high-frequency activity could be linked to the reallocation of neural resources required to manage task complexity, further improving DT performance.

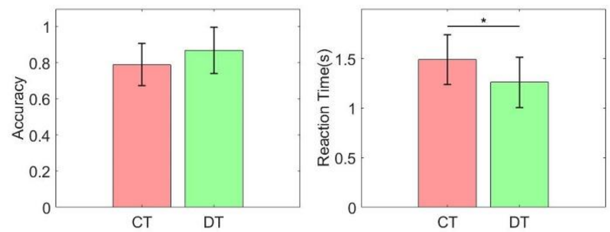

Figure 1: Accuracy and Reaction Time

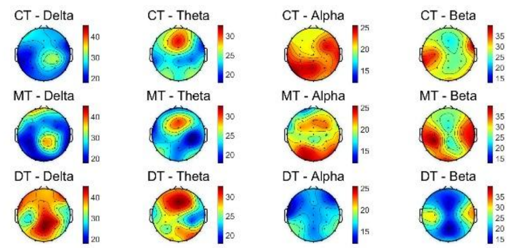

Figure 2: Frequency-Band-Specific Topographic Maps for Three Tasks

Conclusions

DT enhances frontal, with increased low-frequency EEG power and reduced Beta activity, reflecting higher cognitive demands. These findings highlight DT's neural mechanisms and its potential as an effective rehabilitation approach for stroke patients.

Acknowledgments

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References

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