

Introduction

Background:

Parkinson disease (PD) is associated with degeneration of dopaminergic neurons in basal ganglia, which subsequently affects motor function in the human brain [1]. Research has shown that PD patients demonstrate longer reaction time (slower movement) for initiation and inhibition of motor responses in the hand modality [2].

Previous studies have found that slower reaction time in PD can be due to impaired temporal processing in these patients. PD patients were reported to exhibit impairment in temporal estimation and discrimination tasks and also have shown difficulties in generation of self-paced time intervals during finger tapping tasks [3]. In addition, motor timing deficits have been reported in PD patients during speech production and hand movement [2,3]. Although previous studies have shed light on neural and behavioral neural mechanisms of impaired motor timing in PD, less studies have explored possible ways to improve motor timing deficits in speech and hand movement.

Objectives:

This project's purpose is to investigate effects of High-Definition transcranial Direct Current Stimulation (HD-tDCS) on neural and behavioral mechanisms of motor timing during speech production and hand movement and to validate the application of HD-tDCS for improving motor symptoms in PD. Existing studies show that HD-tDCS can induce neuroplasticity, reorganization of brain function, leading to improved functional behavior [4,5]. This suggests that HD-tDCS can be used as an effective method to restore functional mechanisms that are impaired as a result of neurological damage in PD.

The primary objective of this study was to determine effects of HD-tDCS over left frontal on reaction times and neural responses during initiation of speech production and hand movements in PD.

Methods

Subjects:

12 PD patients were enrolled in the present study. PD patients were on dopaminergic medications with different dosage to alleviate their motor symptoms.

Procedure:

Half of Patients were randomly assigned to receive Cathodal HD-tDCS over the left frontal, and the remaining half received sham stimulation on a non-target area. After stimulation, event-related potentials (ERPs) were recorded while subjects were visually-cued to prepare to produce a steady vocalization of a vowel sound or press a button in a randomized order, and to initiate the cued movement following the onset of a go signal on the screen. The time interval between visual cue and go signal was temporally-predictable (see figure 1). For each subject, measures of reaction time and also ERP analysis were computed for speech and hand movement initiation.

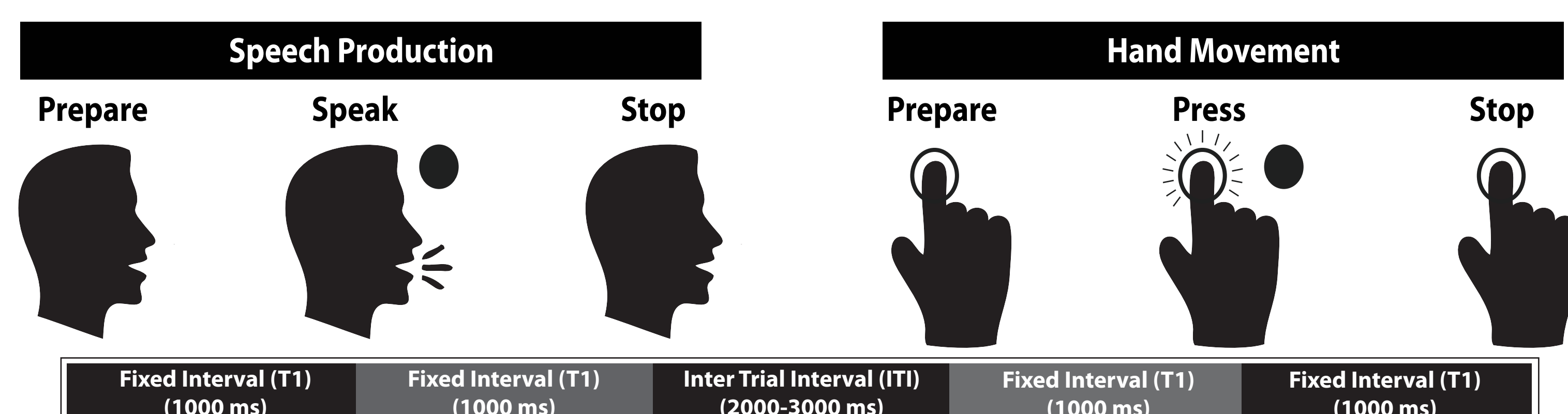


Figure 1. Experimental design.

Methods (continued)

Stimulation configuration: Figure 2 shows the follow of current to left ventral motor cortex.

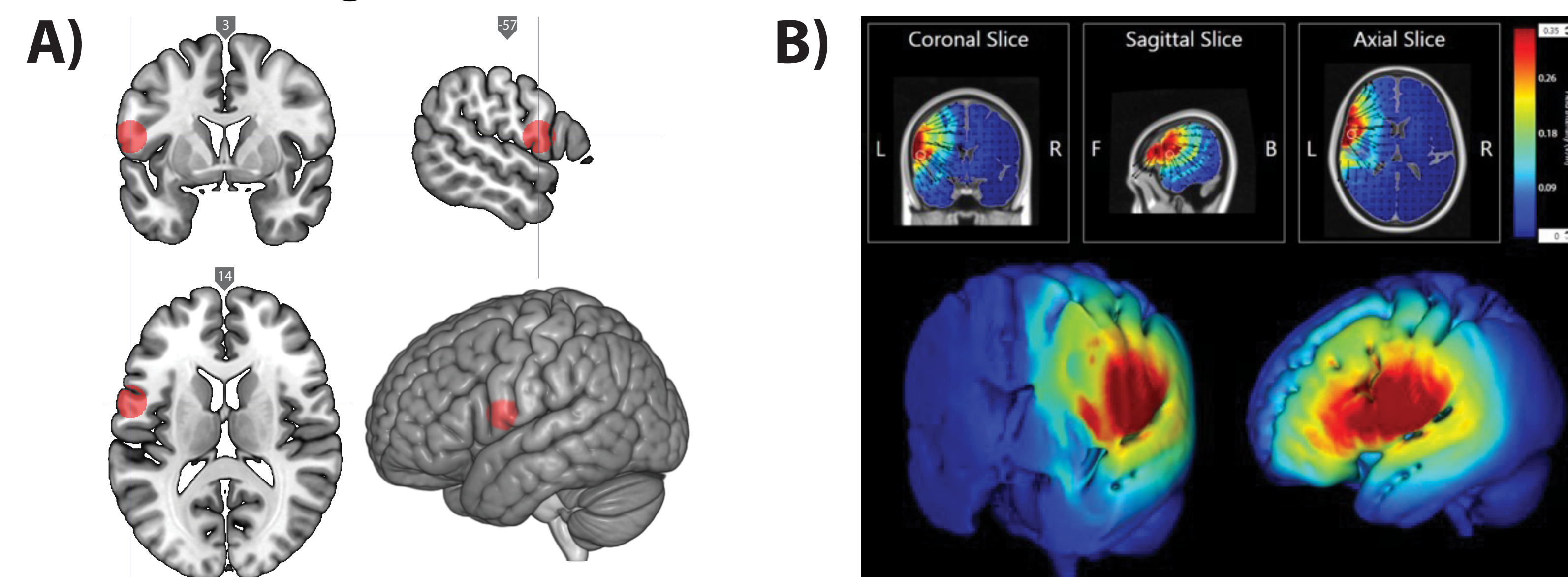


Figure 2. A) The anatomical position of the target area over the left ventral motor cortex (MNI: x=-57, y=3, z=14). B) The reconstructed pattern of current flow intensity for Cathodal HD-tDCS.

Results

Behavioral Results:

PD patients who received Cathodal stimulation exhibited significantly faster motor reaction time than patients who received sham for both speech production and hand movement (figure 3)

ERP Results:

Results showed the attenuation of ERP activities following cathodal vs. sham at -100 to 0 ms before speech production and hand movement. The topographical distribution maps of ERP activities are depicted for speech and hand movement initiation following cathodal and sham stimulations in Fig. 4A and 4B, respectively. Cathodal stimulation significantly attenuated ERP activities compared to sham over the frontal electrodes for speech production (Fig. 4C) hand movement (Fig. 4D).

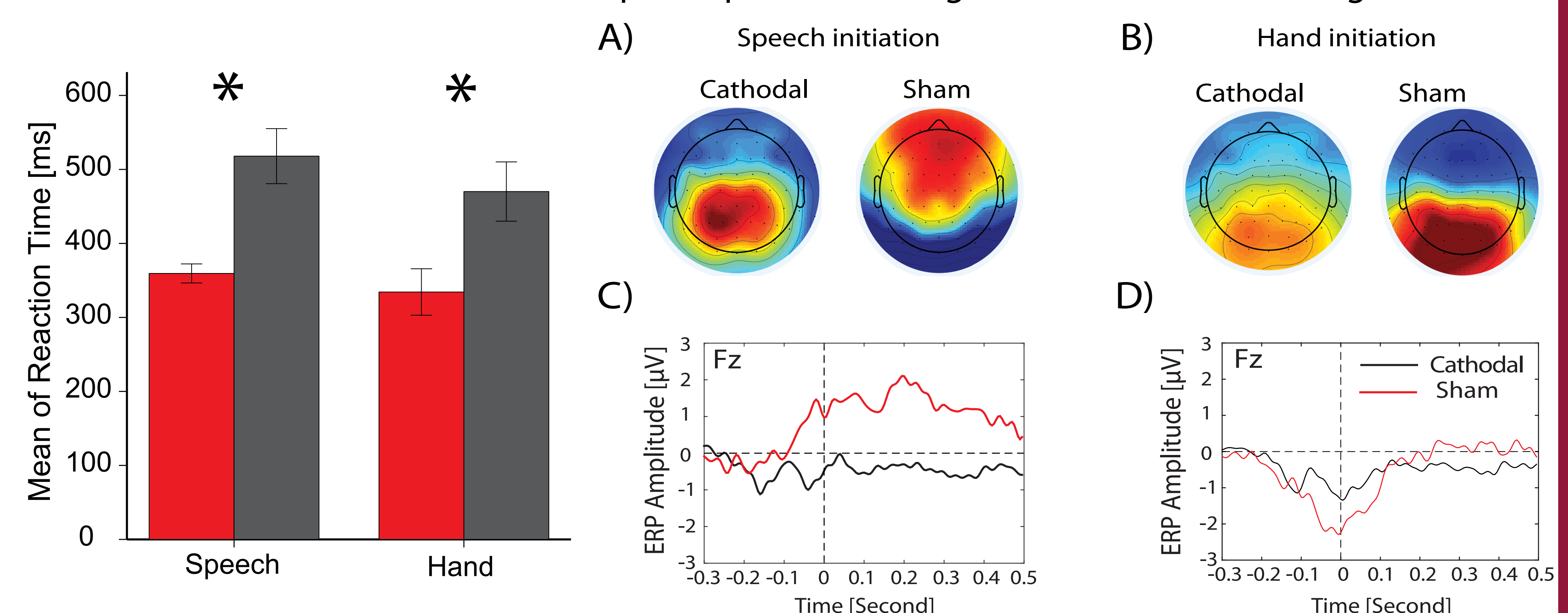


Figure 3. Reaction time for cathodal and sham

Figure 4. ERP response for movement initiation

Discussion

Our findings indicate that Cathodal stimulation can ameliorate motor timing deficits in PD patients.

We suggest that the attenuation of premotor neural activities over frontal and parietal electrodes, as indexed by reduced amplitude of ERP responses, is a neural correlate of improved temporal processing during planning phase of speech production and hand movement in PD patients.

Faster motor reaction time and attenuated ERP activities after cathodal stimulation over frontal cortex may be an indicative of improvement in the dysfunctional fronto-basal ganglia circuits that subserve temporal information processing for speech and hand movement initiation.

References

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