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# The Impact of Repeated TMS on the Microstates of Electroencephalography in patients with Heroin Addiction

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## Abstract

Transcranial magnetic stimulation's therapeutic benefits in the treatment of substance use disorders are receiving attention; nonetheless, the majority of prior research examined these benefits using subjective assessments. For patients with heroin addiction, objective microstate analysis based on electroencephalography (EEG) is crucial for assessing the effectiveness of transcranial magnetic stimulation. Using microstate markers, we examined dynamic changes in brain activity in heroin addicts after transcranial magnetic stimulation. Intermittent theta-burst stimulation (iTBS) was administered to 32 individuals over the left dorsolateral prefrontal cortex.

**Keywords:** Transcranial magnetic stimulation; Cortex; Addiction

## Introduction

SUDs are significant issues in terms of social, legal, and public health. Illegal opioids are among the most commonly used substances that lead to addiction and are to blame for a number of fatalities each year in the United States (Browne et al., 2020). At least 730,000 people in China were exposed to such drugs in 2020, usually heroin (Wang et al., 2022). Opioids like heroin have high addictive properties (Nutt et al., 2007). As heroin users quickly build up a high tolerance that commonly results in heroin overdose, heroin addiction (HA) continues to be a complex social issue that disturbs health globally [1,2].

### Parametric state indicators

It is common practise to utilise electroencephalography (EEG) to examine brain dysfunction in various samples. Many EEG analytical techniques can be used to quantify the temporal dynamics of EEG signals and the location of brain sources. The most objective and reliable of these is EEG microstate analysis based on topographic grouping of scalp electric fields. Also, it optimises the spatial information present in the EEG data and is straightforward to carry out. High temporal resolution mapping of large-scale cortical activity, spatial organisation, and temporal dynamics is made possible by this research. Furthermore, modifications in EEG microstates are a result of the brain network's dysfunction [3, 4].

According to Michel and Koenig (2018), the EEG microstate could depict the spatial and temporal properties of resting states and reflect the nonlinear and discontinuous morphological changes of the brain's electric field. First off, resting-state EEG signals' scalp voltage topography does not fluctuate erratically or continually. Second, periods of quasi-stable scalp EEG topography that last for 60–120 ms before quickly changing into a new map configuration are known as broad-band spontaneous EEG activity. A modified pattern classification approach has been used to identify four typical microstate classes. These classes were consistently found in many investigations and could account for 80% of the variance in EEG data [5, 6].

Moreover, some significant resting-state networks found using functional magnetic resonance imaging are connected to these classifications. Microstate class A corresponds with the auditory networks involved in speech processing, class B with the imaging network, class C with the salience networks, and class D with the attentional networks, whereas class A also correlates with the salience networks. The following are the five most often used microstate time parameters: average duration, frequency of occurrence, coverage, global explained variation, and transition probability [7, 8].

## Conclusion

In order to investigate reliable parameters and efficient mechanisms of iTBS for treating patients with HA, we integrated EEG techniques with a non-invasive brain stimulation instrument. In the HA post-test group, we discovered that the frequency, persistence, and contribution of microstate class A dramatically increased. The centre of the most comparable clusters could be located using K-means, and the F1 score was 81.5% when the HA post-test and HC groups were considered the baseline [9, 10].

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## Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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