



Pre-Stimulus Neural Dynamics Predict TMS Responses: The Role of Fractal Dimension and Oscillatory Activity

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INTRODUCTION

The brain operates near **'criticality'**, balancing stability and adaptability to function optimally. **Deviations** from this state can **alter brain responses** and indicate the presence of **neurological disorders**.

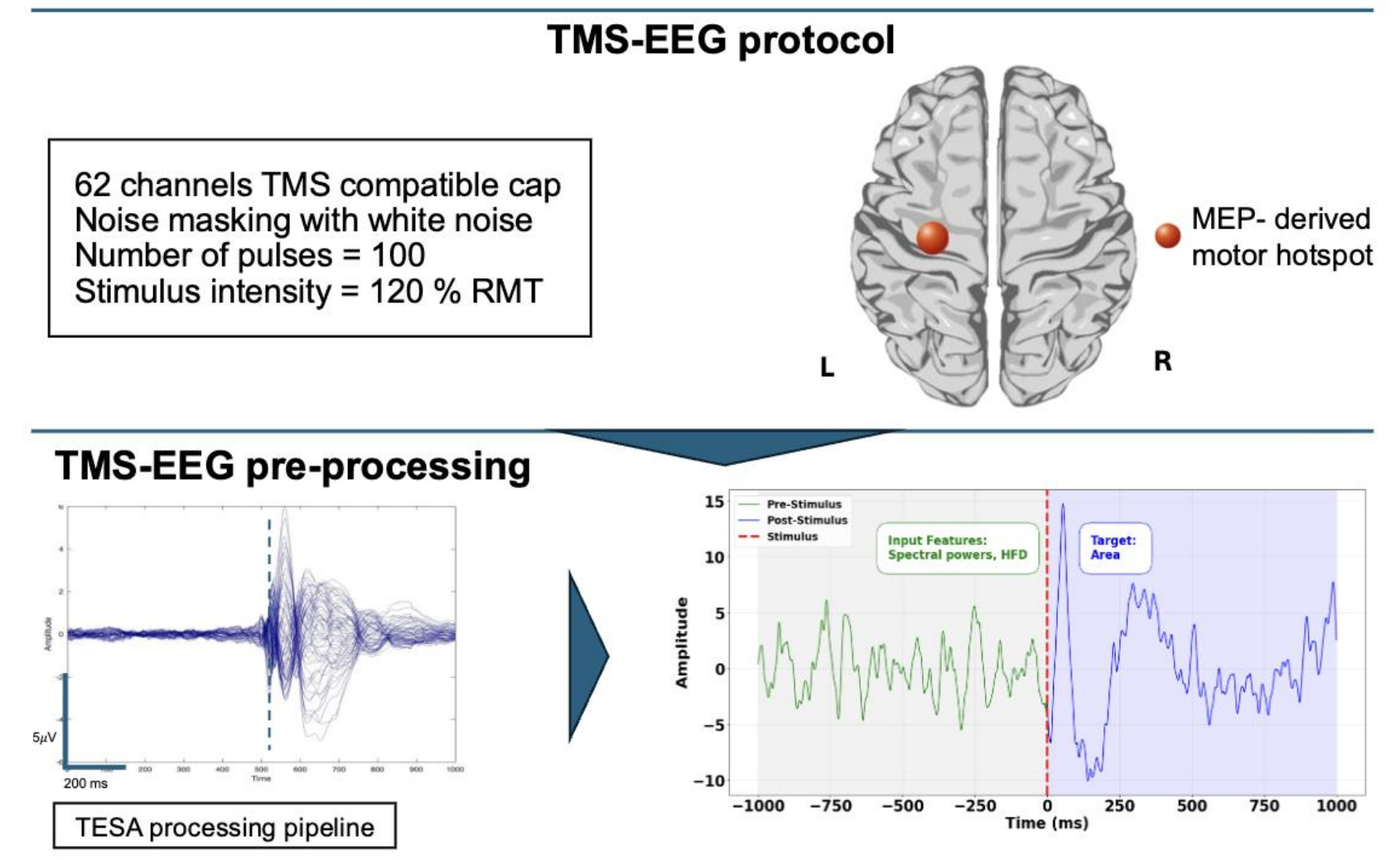
TMS-EEG is a powerful tool for studying criticality and the brains' response to perturbation.¹

We examine how **pre-stimulus features** of activity (i.e. power in different frequency bands) and **signal complexity** influence the variability of the stimulus-related **TMS-evoked potential**.

METHODS

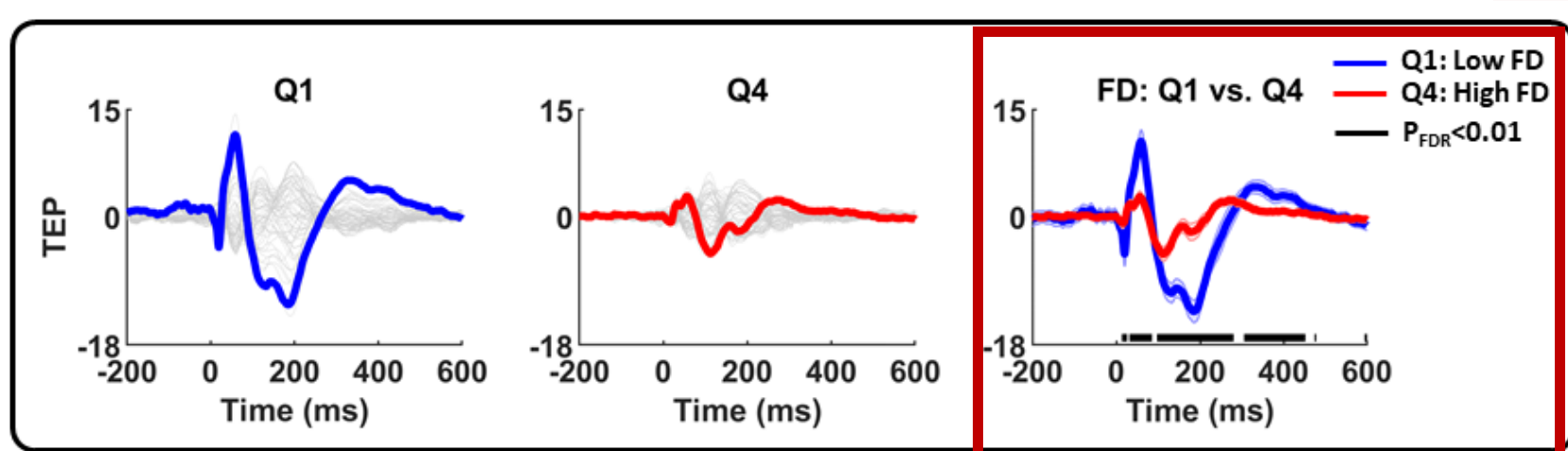
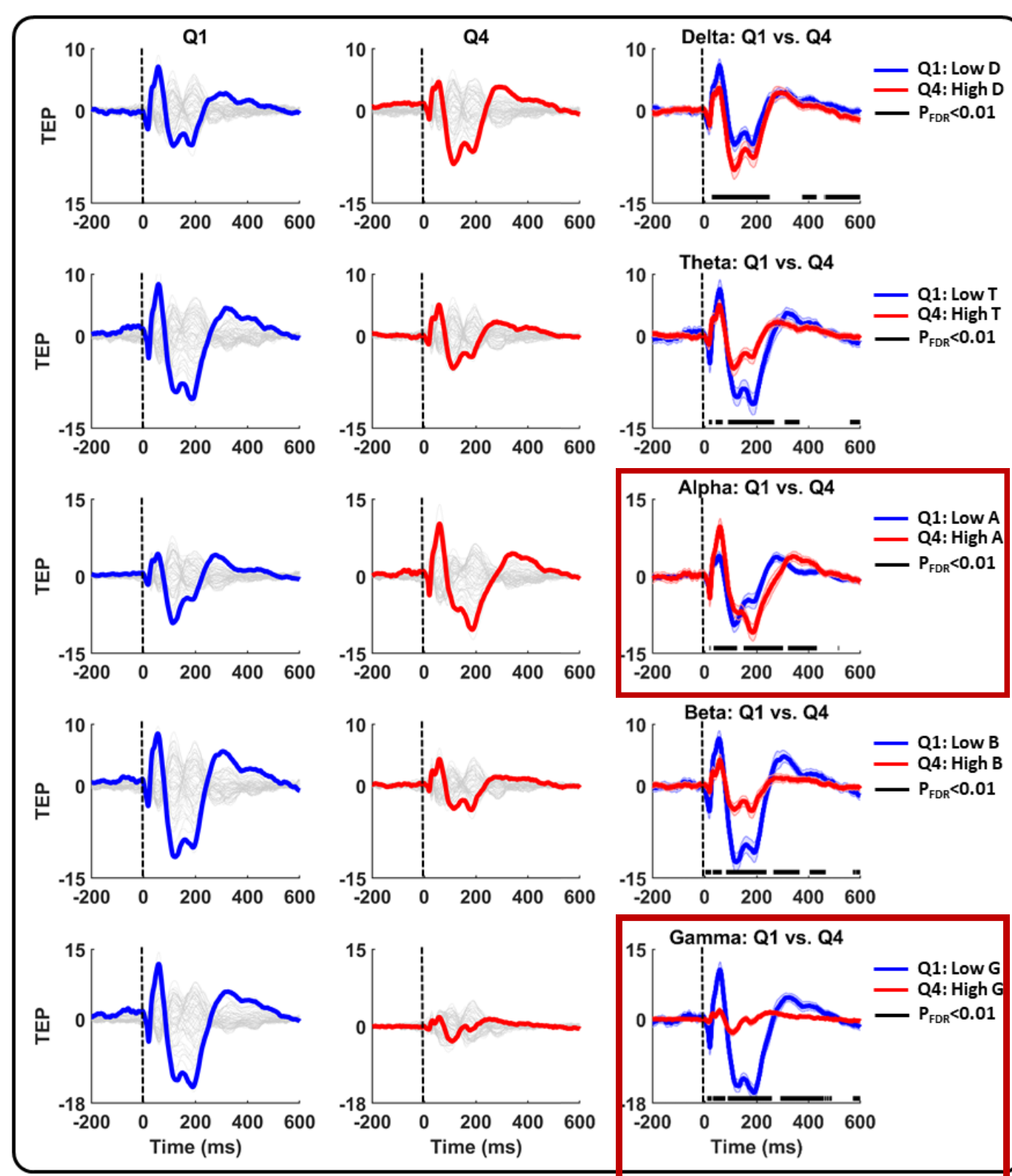
We used a publicly available TMS-EEG dataset from **20 healthy individuals**.² TMS was applied to the **left motor area (M1)**. We analyzed pre-stimulus power across frequency bands and **Higuchi's Fractal Dimension (HFD)**,³ a measure of signal complexity. Using machine learning, we examined the relationship between pre stimulus estimated features and post stimulus TEP variability across trials.

Flowchart of analysis

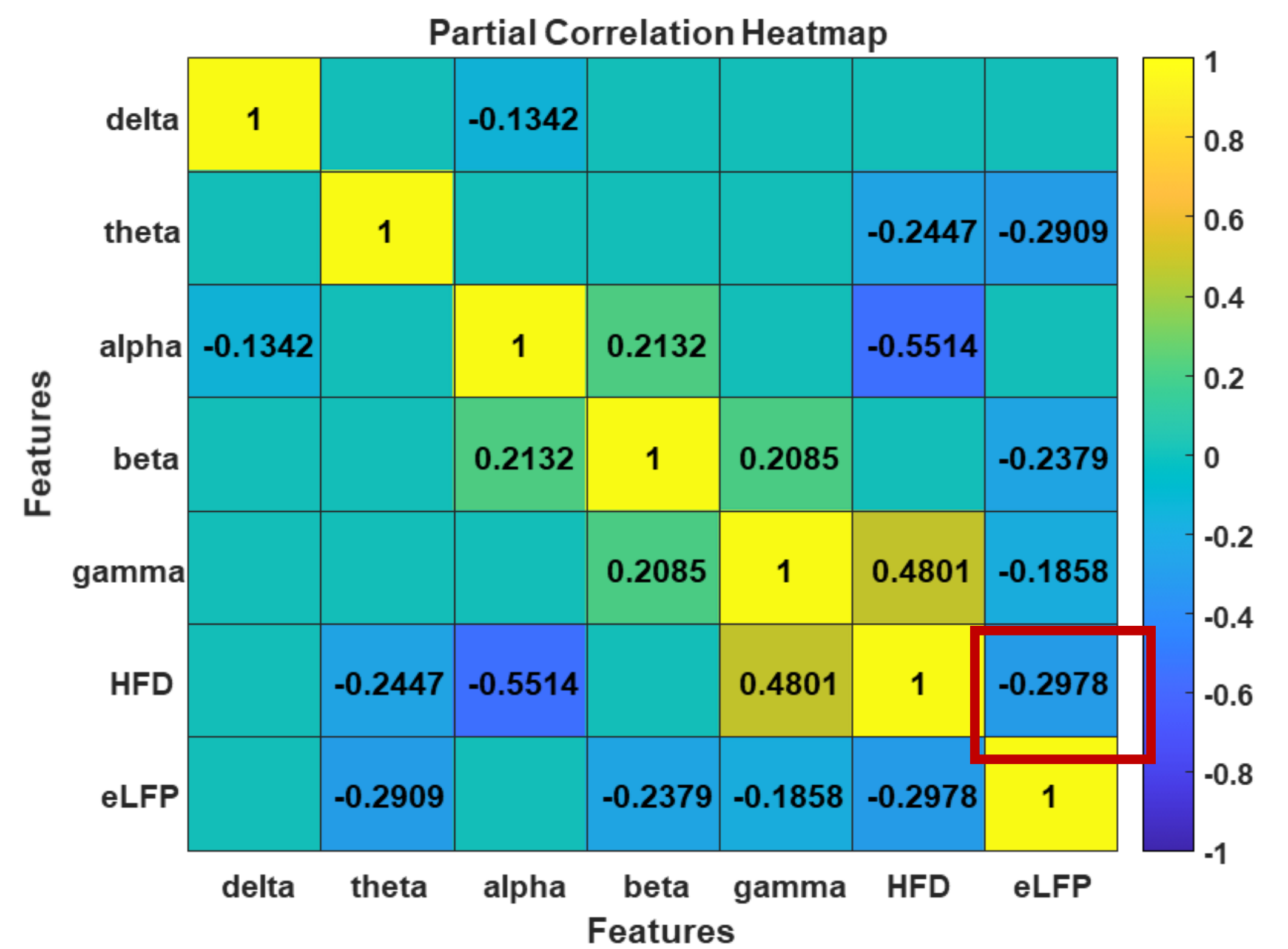


RESULTS

- Stronger TEPs** were measured when pre-stimulus activity contained **lower gamma power** and **higher alpha power**.
- Lower HFD** pre-stimulus values, reflecting less complex baseline activity, were associated with **increased TEP amplitudes**.

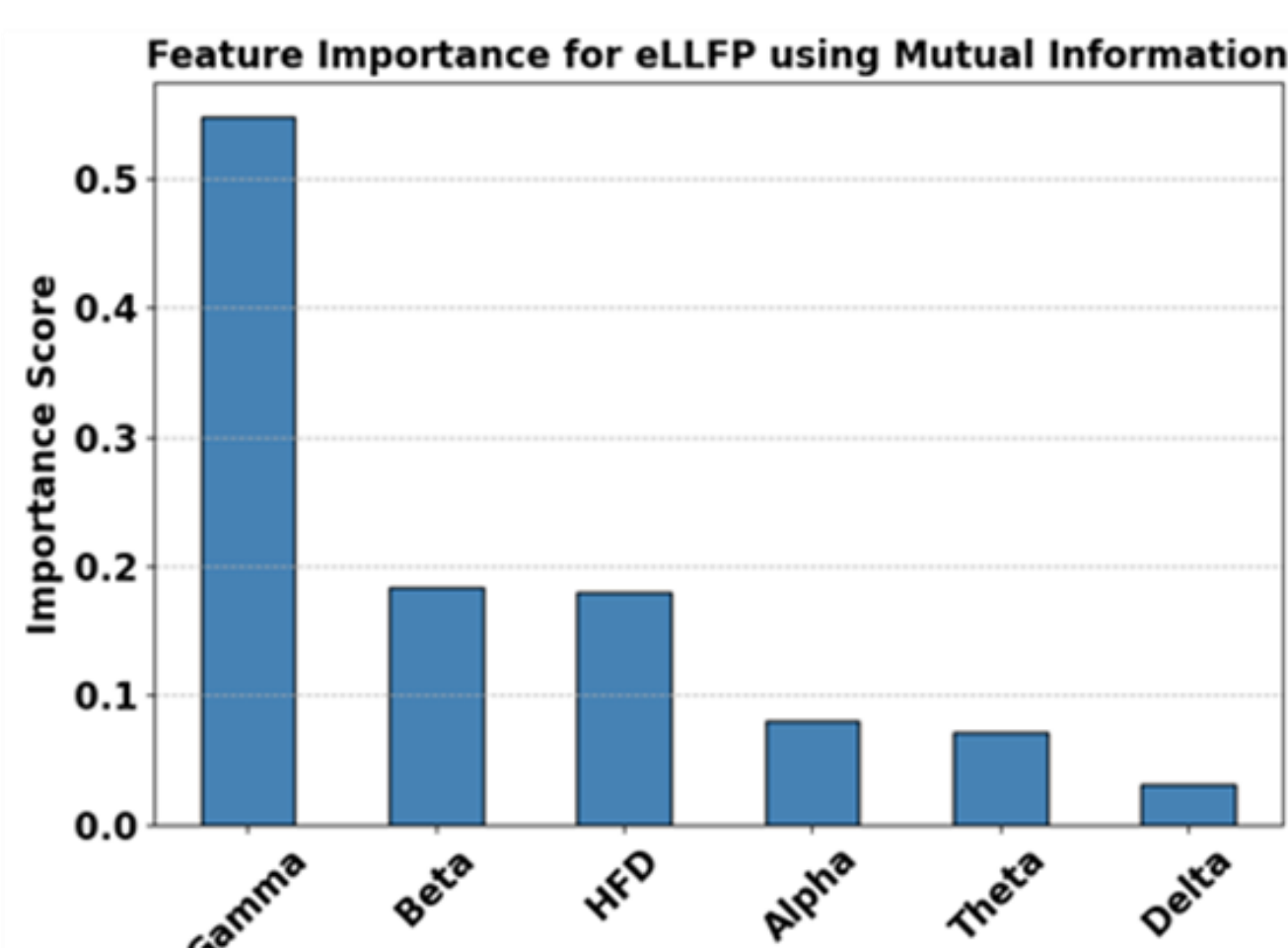
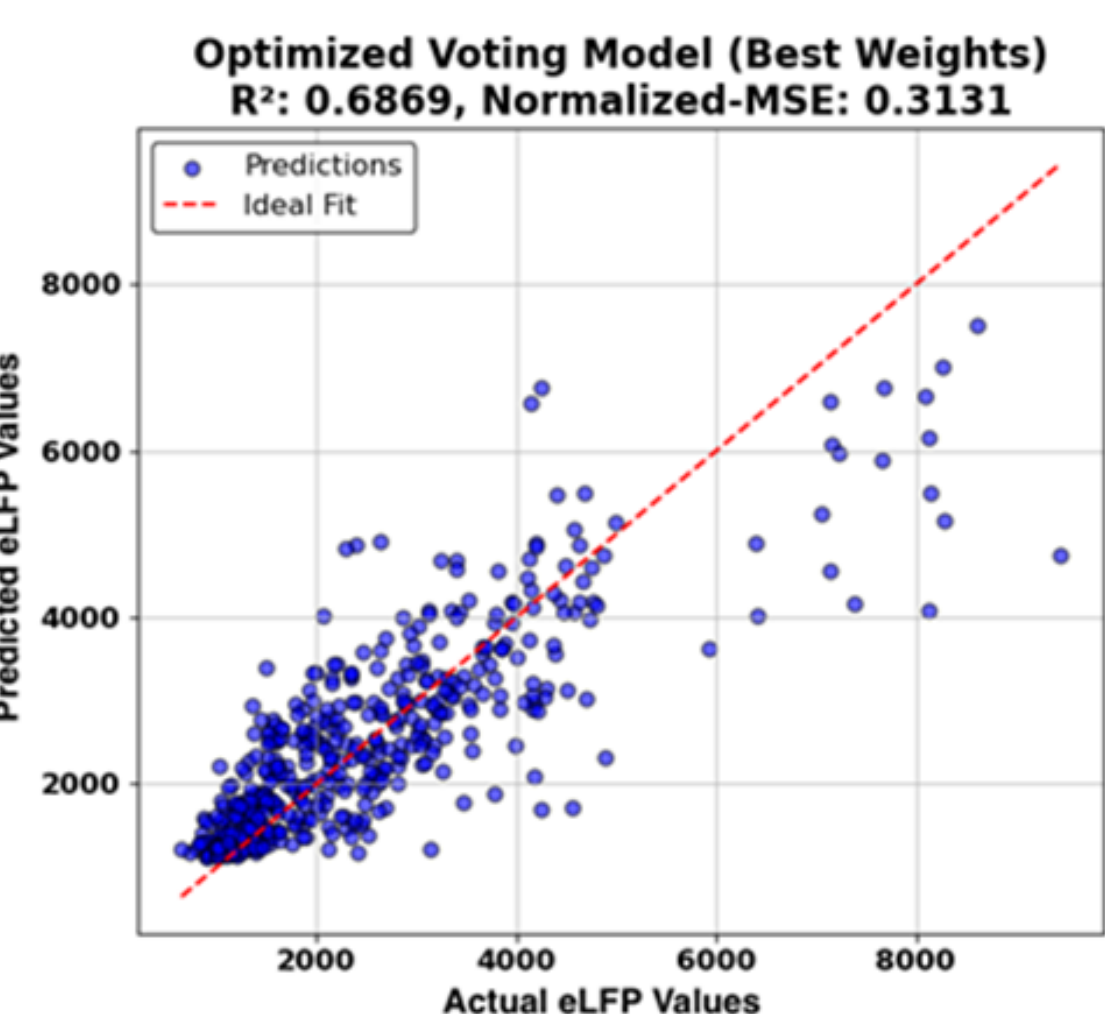


A partial correlation analysis showed that **HFD** was the **most influential feature** in predicting TEPs eLFP ($R=-0.30$).



RESULTS

Machine learning models provided accurate **post-stimulus TEP predictions** using the **pre-stimulus EEG features** ($R^2=0.69$).



DISCUSSION

- Reduced gamma power** and **fractal dimension** were associated with **stronger TEP amplitudes**.
- Higher gamma power and increased HFD, indicating chaotic neuronal dynamics, dampened perturbation responses.
- States closer to **order** may **increase responsiveness**.
- The **opposite effect of alpha power** highlights the frequency-specific nuances of perturbability and criticality.

These findings may be relevant for **therapeutic approaches** using **non-invasive brain stimulation** to **optimize treatment response**

REFERENCES

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