Decoding of cognitive flexibility state using behavior and local field potentials

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Background

Direct measurement of cognitive processes that guide human behavior is a key challenge in the cognitive sciences. Such cognitive states can be estimated through brain activity and/or behavioral responses. In this work, we estimated a cognitive flexibility state using behavior and neural data recorded during the performance of a cognitive task. Furthermore, we used striatal electrical stimulation to modulate the estimated state.

Methods

Eight human subjects performed a multi-source interference task (MSIT) [1] with simultaneous recordings of reaction time (RT) and local field potential (LFP) from cortical and subcortical brain structures. We stimulated in the dorsal and ventral striatum during some of these trials. We used a state space modeling framework [2] to estimate a cognitive flexibility state from RT. We then related the cognitive state to spectral power of the LFP in theta (4-8 Hz), alpha (8-15 Hz), beta (15-30 Hz), gamma (30-55 Hz) and high gamma (65-200 Hz) bands. A statistically principled procedure was then used to select neural features to formulate a neural decoder for predicting cognitive flexibility state [3].

Results

Striatal stimulation significantly reduced RT across 8 subjects (Figure 1, $p<0.01$). We could use 8-15 neural features to reliably decode the cognitive flexibility state. Cognitive states estimated from neural features and behavior had an average correlation of 0.6. The root mean squared error between these decoded states was 10% of their total range.

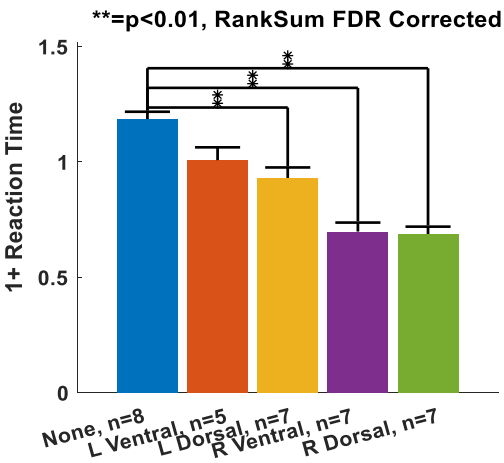

Figure 1: Effect of striatal stimulation on reaction time (RT) during the performance of a multi-source interference task (MSIT).

Conclusions

Using both behavior and neural features recorded during the performance of a cognitive task, we can decode an underlying cognitive flexibility state and control this state using striatal stimulation. This framework can be used to design closed loop electrical stimulation to improve cognitive flexibility in patients with mood and anxiety disorders.

References

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