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Neural oscillation-based detection and modulation of empathy for neuropsychiatric treatment

Stanford scientists have discovered that theta oscillations in the anterior cingulate cortex can detect empathic states, and that targeting the upstream orexin circuit can modulate empathy-related behaviors. This circuit-specific approach addresses a critical gap in treating social deficits in neuropsychiatric disorders such as autism spectrum disorder and schizophrenia, enabling both diagnostic biomarkers and novel therapeutic interventions.

Neuropsychiatric disorders such as autism spectrum disorder and schizophrenia share a core symptom of impaired empathy and reduced prosocial behavior. Current therapies, including social skills training and cognitive behavioral therapy, often show limited and inconsistent efficacy because they do not selectively target the neural circuits underlying these behaviors. Existing pharmacological treatments may have indirect effects on social function, and non-invasive brain stimulation approaches targeting the anterior cingulate cortex lack circuit-level specificity. This variability in treatment outcomes highlights the need for therapies that engage the specific neural mechanisms governing empathy-related behaviors.

Inhibition of the orexinergic circuit from the lateral hypothalamus to the right anterior cingulate cortex (rACC) leads to suppression of rACC theta oscillations and a concurrent reduction in both affective empathy and prosocial comforting behavior. Importantly, temporally precise inhibition of this circuit results in diminished subsequent prosocial behavior, establishing that theta oscillations can serve as a reliable biomarker for empathic states. This discovery enables two complementary approaches: diagnostic tools that use rACC theta activity to assess empathy levels in individual patients, and therapeutic interventions that target the orexin pathway through pharmacological agents or non-invasive brain stimulation techniques such

as transcranial magnetic stimulation and focused ultrasound. Consequently, this circuit-level approach has the potential to transform treatment of social deficits in neuropsychiatric disorders by enabling both personalized assessment and targeted modulation of empathy-related behaviors.

Stage of Development:
Research – in vivo

Applications

- Diagnostic tools for assessing empathy levels in patients with autism spectrum disorder, schizophrenia, and other neuropsychiatric disorders
- Therapeutic interventions targeting the orexin pathway to enhance empathy and prosocial behavior
- Pharmacological agents that modulate orexin receptor activity for treatment of social deficits
- Non-invasive brain stimulation techniques such as transcranial magnetic stimulation and focused ultrasound to regulate theta oscillations
- Personalized treatment planning based on individual rACC theta activity profiles

Advantages

- Targets a specific neural circuit rather than relying on broad-acting interventions
- Provides a biomarker for detecting and monitoring empathic states
- Enables both diagnostic assessment and therapeutic modulation through a single mechanistic framework
- Supports personalized medicine through individualized measurement of theta oscillations
- Offers multiple intervention modalities including pharmacological and non-invasive stimulation approaches
- Addresses an unmet need for circuit-specific treatments of social deficits in neuropsychiatric disorders

Innovators

- Jin Hyung Lee
- Jae Gon Kim

Licensing Contact

Evan Elder

Associate Director, Licensing and Strategic Alliances, Physica

Email