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Neural Oscillation Disruptions as Biomarkers for Early Schizophrenia

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Introduction

Schizophrenia is a complex and heterogeneous psychiatric disorder that affects approximately 1% of the global population. Characterized by a combination of cognitive, emotional and behavioral symptoms, it typically manifests in late adolescence or early adulthood. Despite significant advancements in our understanding of schizophrenia's neurobiology, early diagnosis remains a formidable challenge. Current diagnostic criteria, largely reliant on clinical interviews and observable behavior, often result in delayed treatment, which can exacerbate long-term outcomes. Thus, the identification of reliable, non-invasive biomarkers for early detection is a critical unmet need in psychiatric medicine. Among the most promising avenues of research in recent years is the exploration of neural oscillations-the rhythmic electrical activity of neurons across various frequency bands-as potential biomarkers for schizophrenia. Neural oscillations underlie fundamental brain functions such as perception, memory and attention, all of which are disrupted in schizophrenia. Abnormalities in the synchronization, amplitude and frequency of neural oscillations have been consistently observed in individuals with schizophrenia and those at Clinical High Risk (CHR) for developing the disorder [1].

Description

Neural oscillations are patterns of rhythmic or repetitive neural activity in the central nervous system. They are typically classified according to their frequency ranges: delta (1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz) and gamma (30–80 Hz), though high gamma and ultrafast frequencies are also studied in specialized contexts. These oscillations emerge from the interaction of excitatory and inhibitory neuronal circuits, particularly the coordinated activity of pyramidal cells and interneurons. Different oscillatory bands are associated with distinct cognitive and behavioral functions. For example, delta waves are linked to deep sleep and homeostatic regulation, theta to working memory and navigation, alpha to sensory processing and inhibition, beta to motor control and cognitive integration and gamma to attention, perception and the binding of sensory information. Coherence and synchronization within and across these frequency bands are essential for efficient neural communication [2].

Abnormal neural oscillations have been documented extensively in patients with schizophrenia across various brain regions and frequency bands. Gamma-band oscillations, which are thought to play a key role in perceptual integration and working memory, are consistently reduced in amplitude and synchronization in individuals with schizophrenia. This reduction is most notable during cognitive tasks, such as the Auditory Steady-State Response (ASSR), a paradigm used to assess the brain's ability to track rapid auditory stimuli. Similarly, theta and alpha oscillations show altered patterns in schizophrenia. Reduced theta power during memory tasks and impaired alpha desynchronization during attentional processing have both been reported. These abnormalities are believed to reflect underlying dysfunctions in the cortico-thalamic and cortico-hippocampal circuits, which are vital for executive function and sensory gating. Beta-band oscillations, while less frequently studied, also exhibit disruptions, particularly during motor and cognitive tasks. Aberrant beta activity may contribute to the psychomotor symptoms and planning deficits observed in patients [3].

The generation and modulation of neural oscillations depend on a delicate balance between excitatory glutamatergic and inhibitory GABAergic signaling. In schizophrenia, multiple lines of evidence point to dysfunctions in these systems, particularly within parvalbumin-positive interneurons. These fast-spiking interneurons are crucial for the generation of gamma oscillations through their synchronous inhibition of pyramidal neurons. Postmortem studies of schizophrenia patients have revealed reduced expression of GAD67 (glutamic acid decarboxylase), the enzyme responsible for GABA synthesis, particularly in PV+ interneurons. This deficit likely contributes to impaired gamma synchrony observed in Electroencephalogram (EEG) and Magnetoencephalogram (MEG) studies. Additionally, NMDA receptor hypofunction has been implicated in the pathophysiology of schizophrenia and may disrupt both excitatory and inhibitory oscillatory dynamics. Animal models with NMDA receptor antagonism show reduced gamma and theta activity, mirroring the electrophysiological deficits seen in patients [4].

The predictive value of neural oscillation disruptions lies in their early emergence and stability over time. Studies involving CHR populations have demonstrated that individuals who later transition to psychosis often exhibit distinct oscillatory profiles, including reduced gamma power and impaired theta synchronization. These abnormalities may serve as state-independent traits that identify individuals at highest risk. Moreover, neural oscillations offer several practical advantages as biomarkers. They can be measured non-invasively through EEG and MEG, which are widely accessible and relatively inexpensive. These methods allow for high temporal resolution, capturing rapid changes in brain activity that are critical for understanding dynamic cognitive processes. Machine learning algorithms applied to oscillatory data have shown promise in classifying individuals at risk and predicting conversion to psychosis. Multivariate models that incorporate oscillatory features, cognitive assessments and genetic data can enhance predictive accuracy, paving the way for precision psychiatry approaches [5].

Conclusion

Disruptions in neural oscillations represent a compelling and increasingly well-supported avenue for understanding and identifying early schizophrenia. These rhythmic brain activities are fundamental to cognition, perception and behavior-all domains that are profoundly affected in the disorder. Aberrant oscillatory patterns, particularly in the gamma and theta ranges, are detectable before the onset of full psychosis, making them valuable candidates for early biomarkers. The biological basis of these disruptions, rooted in interneuronal dysfunction, synaptic dysregulation and genetic vulnerability, further supports their relevance to disease pathogenesis. With advances in non-invasive neuroimaging and machine learning, neural oscillations are poised to transform the early diagnosis and personalized treatment of schizophrenia.

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Conflict of Interest

None.

References

1. Akbari, Hesam, Muhammad Tariq Sadiq, Nastaran Jafari and Jingwei Too, et al. "Recognizing seizure using Poincaré plot of EEG signals and graphical features in DWT domain." *Bratisl Lek Listy* 124 (2023): 12-24.

2. Sheffield, Julia M. and Deanna M. Barch. "Cognition and resting-state functional connectivity in schizophrenia." *Neurosci Biobehav Rev* 61 (2016): 108-120.

3. Fan, Yajuan, Yuan Gao, Qingyan Ma and Binbin Zhao, wt al. "Grey matter volume and its association with cognitive impairment and peripheral cytokines in excited individuals with schizophrenia." *Brain Imaging Behav* 16 (2022): 2618-2626.

4. Lalousis, Paris Alexandros, Aanya Malaviya, Rachel Upthegrove and Kareen Heinze, et al. "Trait related aberrant connectivity in clinically stable patients with schizophrenia: A seed based resting state fMRI study." *Brain Imaging Behav* (2022): 2705-2714.

5. Takahashi, Tsutomu, Michio Suzuki, Shi-Yu Zhou and Ryoichiro Tanino, et al. "Temporal lobe gray matter in schizophrenia spectrum: A volumetric MRI study of the fusiform gyrus, parahippocampal gyrus and middle and inferior temporal gyri." *Schizophr Res* 87 (2006): 116-126.

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