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DOI: 10.1002/ird3.97

EDITORIAL

iRADIOLOGY

Ultra-high field magnetic resonance imaging in theranostics of mental disorders

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KEYWORDS
disorders, mental, MRI, theranostics, ultra-high

Mental disorders comprise a range of abnormal states that affect an individual's cognition, emotion, behavior, and social functioning, potentially distorting their perception of reality and seriously impacting their daily life, work, and interpersonal relationships. Mental disorders, including anxiety disorders, depression, schizophrenia, and bipolar disorder, impact not only individuals, but also their families and societies at large. The incidence of mental disorders increased by 31.6% between 1990 and 2007, and this trend continued between 2007 and 2017 (percentage change: 13.5%) [1]. In China, the lifetime prevalence of mental disorders is 16.6% and has been reported to exhibit a trend toward increasing over time [2]. In terms of the global disease burden, mental disorders were reported to account for 5.3% of total disability-adjusted life years in 2019, underscoring their significant impact on public health [3].

Biomarkers derived from magnetic resonance imaging (MRI) provide objective and quantifiable data on both the anatomy and function of the target organ (e.g., the human brain). Because of their non-invasive nature, these MRI-derived biomarkers are increasingly recognized as being among the most clinically feasible tools. Psychoradiology, an emerging radiology subspecialty bridging medical imaging and psychiatry, represents the frontier of neuroimaging applications in the elucidation and evaluation of mental health issues. Since they were introduced in 2016, researchers and clinicians have been developing norms, protocols, and strategies to facilitate the clinical application of psychoradiological techniques [4, 5]. The quantitative analysis of psychoradiological data has potentials for identifying the objective and diagnostic biomarkers with highly predictive value related to mental disorders. Although considerable progress has been made in the field of psychoradiology, further clinical application of imaging-based diagnostics for mental disorders remains challenging, primarily because of limitations in the reproducibility and generalizability of diagnostic models. While psychoradiology also offers potential insights into aberrant brain mechanisms and enhances the interpretability of neuromarkers, its progress appears to be approaching a plateau because of the resolution limitations of current MRI technology at the mesoscopic level. The emergence of ultra-high field MRI (UHF-MRI; typically 7T and above) has provided the

Abbreviations: MRI, magnetic resonance imaging; UHF-MRI, ultra-high field magnetic resonance imaging.

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opportunity to open a new chapter in the development of psychoradiology, adding spatial sampling that yields superior resolution, higher signal-to-noise ratios, increased sensitivity, amplified signal change [6], and enhanced microvascular contribution.

In terms of structural imaging, a UHF-MRI allows the depiction of fine structures and subregions with superior clarity, such as the detailed visualization of the dentate granule cell layer of the hippocampus, which cannot be achieved with low-field MRI [7]. Studies with UHF-MRI have reported that the structural changes of the hippocampal [8] and insular [9] subregions were related to the neural basis of schizophrenia and the improvement of depressive symptoms after medication treatment [10, 11]. The UHF-MRI can enhance the visualization of the gray matter-white matter boundary, thus improving the accuracy of brain segmentation and facilitating the estimation of morphometric metrics like cortical thickness. The improved clarity may ultimately lead to more accurate classification of individuals with psychiatric disorders and healthy population. Iwabuchi et al. compared the classification of gray matter and white matter images obtained at 3 and 7T, and the results revealed that the accuracy, sensitivity, and specificity of classification in 7T images were improved [12].

In terms of functional imaging, the UHF-MRI can better display the blood oxygen level-dependent signal in the cerebellar region given its high resolution [13], leading to more precise calculations of brain connectivity. In a study of patients with depression, the UHF-MRI detected functional abnormalities in emotion-related neural circuits [14]. The application of UHF-MRI may also identify subtle alterations in the whole-brain network in psychiatric disorders [13, 15]. Additionally, the UHF-MRI can shorten the scanning time, benefiting both the examination process and image quality in clinical settings. Recent studies using UHF-MRI have corroborated findings from previous low-field intensity research on mental disorders [16], establishing connections between abnormalities in these disorders across multiple scales. Limongi et al. reported a link between changes in glutamatergic neurotransmission and disrupted functional connectivity [17].

UHF with magnetic resonance spectroscopy and chemical exchange saturation transfer imaging techniques have enhanced sensitivity and specificity for metabolite detection. The improved stability of the magnetic resonance spectroscopy baseline at ultra-high field strengths enables higher resolution in multi-dimensional spectral imaging and more accurate spectral numerical analysis. Wijtenburg et al. identified case-control differences in glutamine, glutamate, gamma-aminobutyric acid, and lactic acid across five brain regions of interest in individuals with schizophrenia [18]. Reid et al. reported a correlation between the level of gamma-aminobutyric acid and cognitive function in individuals with schizophrenia [19]. Furthermore, Roalf et al. used a spatially resolved two-dimensional method that was based on glutamate chemical exchange saturation transfer and found an overall decrease in glutamate levels in individuals with early-stage psychosis [20].

UHF-MRI could potentially revolutionize the landscape of psychoradiological research in the near future. Its superior signal-to-noise ratio, resolution, and sensitivity enable us to explore fine structural and functional abnormalities in the human body that were difficult to detect in the past. The application of UHF-MRI in psychoradiology is expected to reveal novel psychopathological mechanisms underlying mental disorders. In light of these advancements, we encourage more researchers to harness UHF-MRI in their ongoing investigations and innovations, promoting technological progress and accelerating the translation of UHF-MRI findings in the realm of mental disorders.

AUTHOR CONTRIBUTIONS

Yajun Yin: Writing—original draft (equal). **Qiyong Gong**: Writing—review & editing (lead).

ACKNOWLEDGMENTS

The authors thank Professor Bo Gao for the invitation to write this review.

CONFLICT OF INTEREST STATEMENT

The authors declares no conflicts of interest.

DATA AVAILABILITY STATEMENT

There are no data for this review.

ETHICS STATEMENT

Not applicable.

INFORMED CONSENT

Not applicable.

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