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The Virtual Brain: Linking Theory and Data Towards Understanding Pathophysiological Processes

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The effectiveness of therapies and preventive strategies for nervous system disorders relies on our ability to customize treatments to the unique needs of each individual. Digital twins of the nervous system have the potential to revolutionize precision medicine. As a result, one of the key research and innovation areas for advancing brain health is the development of digital twins for both healthy and diseased individuals. While recent progress has underscored the potential of this approach and addressed some technical challenges in building digital twins to support decision-making in neurology and psychiatry—ranging from prevention and diagnosis to personalized care and therapy—many questions remain before these systems can be fully translated into the clinical practice. Among the remaining challenges there are: 1) the acquisition of new data types and the integration large datasets 2) the definition of relevant biomarkers, 3) the inclusion of physiologically meaningful details into synthetic models, 4) the effective personalization of custom models. These obstacles are being addressed by combining mechanistic models, artificial intelligence, and multimodal data. We will explore two examples, namely Parkinson's disease and Multiple Sclerosis, where these tools have started to be integrated to create personalized models.

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