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Connectome 2.0: Next-generation connectomics and microstructure MRI scanner for imaging of human brain circuits across scales

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Defining the connectome, the complete matrix of structural connections between the nervous system nodes, is an enormous challenge for human systems neuroscience due to the sheer range of scales that must be bridged. Here, we report the design of the next-generation human connectomics and microstructure 3 Tesla MRI scanner capable of imaging across the macroscopic, mesoscopic, and microscopic scales with the strongest gradients ever engineered for in vivo human imaging. We constructed a three-layer head-only gradient coil optimized to minimize peripheral nerve stimulation while achieving ultra-high gradient strength of 500 mT/m and ultra-fast slew rate of 600 T/m/s, corresponding to 18-fold greater gradient performance than state-of-the-art clinical gradient systems. Further gains in sensitivity were achieved by integrating a 72-channel in vivo head coil and 64-channel ex vivo whole brain RF coil with built-in field monitoring for the highest data fidelity. We demonstrate mapping of fine white matter pathways and inferences of cellular and axonal size and morphology approaching the single micron level, offering an order-of-magnitude boost in sensitivity for imaging across scales in the living human brain.

Keywords: Connectome, Human Neuroscience, Integrated Approaches, Neuroimaging (invasive, noninvasive imaging)