LAYMAN'S SUMMARY

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This review delves into recent advancements in task-based functional Magnetic Resonance Imaging (fMRI) techniques at ultra-high field strengths (7T and above), which have greatly enhanced our comprehension of the human brain's inner workings. These techniques enable precise investigations of brain activity during specific cognitive tasks. The focus lies on exploring neural responses and their correlation with cognitive processes, particularly in the context of sub-millimeter fMRI at the laminar and columnar level.

The review examines well-known methods of Blood Oxygenation Level-Dependent (BOLD) fMRI and addresses their limitations. It highlights rapid BOLD fMRI strategies, including simultaneous multi-slice (SMS) acquisition, parallel imaging, and line-scanning fMRI, which facilitate the exploration of sub-millimeter scales with higher temporal resolution. Additionally, alternative contrast mechanisms are discussed, such as cerebral blood volume (CBV) imaging using vascular space occupancy (VASO) contrast and direct measurements of cerebral blood flow (CBF) through arterial spin labeling (ASL). These techniques hold promise for studying specific cortical layers and columns, unveiling intricate neural structures and functional organization.

These advancements in task-based ultra-high field fMRI provide valuable insights into the neural mechanisms underpinning cognitive processes, paving the way for more reliable mesoscopic resolution and sub-second temporal resolution in fMRI studies. As the field progresses, the integration of these cutting-edge techniques with hardware advancements and post-processing methods promises to unlock even more detailed and comprehensive understandings of brain function, ushering in new avenues for cognitive neuroscience research.