

A. Magnetic / MRI-Related (Non-Invasive)

1. **Functional Connectivity MRI (fcMRI)**
Not the same as BOLD; uses correlation structure across voxels. (Probably implicit, but useful to explicitly list.)
2. **Resting-State fMRI (rs-fMRI)**
Now its own category of technique with unique analytical methodology.
3. **Magnetic Particle Imaging (MPI)**
A new imaging modality using superparamagnetic nanoparticles for high temporal resolution neurovascular imaging.
4. **Susceptibility-Weighted Imaging (SWI)**
Useful for venous blood mapping and hemodynamic activity in vivo.
5. **Quantitative Susceptibility Mapping (QSM)**
Reconstructs iron content and hemodynamic changes related to function.
6. **Functional MRS (fMRS)**
Measures neurotransmitter fluctuations (Glu, GABA) in vivo in real time.
7. **Magnetic Resonance Elastography (MRE)**
Measures brain tissue stiffness changes associated with neural activity and neurovascular coupling.
8. **Chemical Exchange Saturation Transfer (CEST) fMRI**
Detects metabolites and neurotransmitters via exchangeable protons, providing molecular functional imaging.
9. **Microvascular Volumetric Pulsatility Mapping**
Combines VASO and ASL at ultra-high field to map pulsatile flow in cerebral microvessels linked to activity.
10. **Neurite Orientation Dispersion and Density Imaging (NODDI)**
Multicompartment diffusion MRI model to estimate neuronal microstructure and density in vivo.
11. **Neuromelanin-Sensitive MRI**
Detects neuromelanin in substantia nigra and locus caeruleus as a proxy for catecholaminergic neuron function.
12. **Free-Water Diffusion Imaging**
Removes extracellular free water contributions from diffusion signals to assess
13. **Optically Pumped Magnetometer MEG (OPM-MEG)**
Room-temperature, scalp-proximate optically pumped magnetometer arrays for high-sensitivity, flexible MEG recordings in naturalistic and mobile settings.
14. **Hyperpolarized 13C Metabolic MRI**
Real-time metabolic flux imaging using hyperpolarized 13C tracers to measure rapid changes in brain energy metabolism linked to neural activity.
15. **[NEW] Magnetic Resonance Fingerprinting (MRF)**
Rapid, quantitative multiparametric tissue mapping for assessing dynamic physiological changes during brain activity.
16. **[NEW] VASO (Cerebral Blood Volume fMRI)**
Non-BOLD fMRI technique sensitive to cerebral blood volume changes for layer-specific functional imaging.

17. **[NEW] Q-ball Imaging**
High angular resolution diffusion imaging (HARDI) technique for resolving complex fiber crossings in white matter.
 18. **[NEW] Continuous Arterial Spin Labeling (CASL)**
Non-invasive perfusion MRI method using continuous RF inversion of arterial water for quantitative CBF mapping.
 19. **[NEW] Pulsed Arterial Spin Labeling (PASL)**
ASL variant using short RF pulses to label arterial blood, offering different trade-offs for perfusion imaging.
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B. PET / Radiotracer Advances

20. **Fiber-Coupled PET Detectors (minimally invasive)**
Enables localized in vivo PET from freely moving animals.
21. **Neuroimmune PET Ligands (TSPO, CSF1R etc.)**
For studying microglial/astrocyte activation dynamically. (Not purely activity, but increasingly part of functional neuroimaging.)
22. **Total-Body PET Imaging**
Enables whole-brain dynamic imaging with unprecedented temporal resolution and sensitivity.
23. **Positronium Lifetime Imaging**
Emerging PET technique providing information about tissue microenvironment during neural activity.
24. **Synaptic Vesicle Glycoprotein 2A (SV2A) PET Imaging**
Uses tracers like [¹¹C]UCB-J to quantify synaptic density in vivo.
25. **Mitochondrial Complex I PET Imaging**
Employs [¹⁸F]BCPP-EF to assess mitochondrial function and energy metabolism related to neural activity.
26. **CSF1R PET for Neuroinflammation**
Tracers like [¹¹C]CPPC to image microglial activation during brain processes.
27. **Positron Emission Metabolic Tracing with Short-Lived Isotopes (rapid kinetic PET)**
High-temporal-resolution PET protocols using short-lived radiotracers and fast kinetic modeling to track sub-minute metabolic changes associated with neural events.
28. **[NEW] μ-opioid Receptor PET (^{[11}C]carfentanil)**
In vivo imaging of endogenous opioid release during various behavioral states.
29. **[NEW] Dopamine D2/D3 Receptor Occupancy PET**
Measures dynamic changes in dopamine transmission using radioligands like [¹¹C]raclopride.
30. **[NEW] Cerebral Metabolic Rate of Oxygen (CMRO₂) PET**
Quantitative imaging of oxygen metabolism coupled to neural activity using ¹⁵O-labeled tracers.
31. **[NEW] Astrocyte-Specific PET Tracers (¹¹C-deuterium-L-deprenyl)**
Targets monoamine oxidase B in astrocytes for glial activity mapping.

C. Electrophysiology & Implant Technologies

32. Neuropixels Probes (latest gen)

Not just "multielectrode"; Neuropixels constitute a distinct class due to ultra-high channel count (1,000+), used *in vivo* widely.

33. Silicon Probe Laminar Recordings

For cortical column laminar activity (V1, CA1).

34. High-Density “ECoG Grids” (Neuropixels–ECoG hybrids)

New grids with thousands of micro-electrodes recordings across cortex.

35. EMG-Assisted Brain–Body Coupled Recording

Used in behaving animals to integrate motor output with neural activity.

36. Flexible Bioelectronic Neural Interfaces

Conformable electrode arrays that minimize tissue damage and enable stable long-term recordings.

37. Transparent Graphene Microelectrode Arrays

Allow simultaneous electrical recording and optical imaging/optogenetics.

38. Ultrasonic Neural Dust Motes

Wireless, millimeter-scale implants for chronic neural recording.

39. Optetrode Recordings

Hybrid probes combining electrical electrodes with optical fibers for simultaneous recording and stimulation.

40. CMOS-Integrated Neural Probes

On-chip amplified high-density probes for low-noise *in vivo* recordings.

41. Sharp Electrode Intracellular Recordings

Historical method using fine glass micropipettes for high-impedance intracellular potential measurements.

42. Wireless High-Density Neural Probes (wireless Neuropixels variants)

Fully wireless, implantable high-channel-count probe systems enabling untethered large-scale neural recordings in freely moving animals.

43. Autonomous Robotic In Vivo Patch-Clamp (AutoPatch / Robopatcher)

Automated robotics-enabled intracellular patch-clamp in awake or anesthetized

44. Graphene Field-Effect Transistor Neurochemical Sensors (gFETs)

Implantable gFET biosensors for direct, high-sensitivity, real-time detection of neurotransmitters and neuromodulators *in vivo* with electrical readout.

45. [NEW] Tetrode Recordings

Historical method using four-wire bundles for extracellular recording with improved single-unit isolation.

46. [NEW] Juxtacellular Recording and Labeling

Technique for extracellular recording followed by intracellular labeling of recorded neurons.

47. [NEW] Carbon Fiber Microelectrodes
Miniatuerized electrodes for electrochemical detection of neurotransmitters with fast-scan cyclic voltammetry.
48. [NEW] Floating Microelectrode Arrays
Untethered microelectrodes that move with brain tissue for stable chronic recordings.
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D. Optical / Imaging-Based Techniques

49. Light-Sheet Fluorescence Microscopy (LSFM) In Vivo
Now used in small transparent animals (zebrafish, larval models). Technically in vivo and provides whole-brain fast activity imaging.
50. Swept Confocally-Aligned Planar Excitation (SCAPE) Microscopy
High-speed volumetric neural imaging in freely moving animals.
51. Structured-Light 3D Imaging of Cortical Hemodynamics
Used to map neural activity via intrinsic signals & hemodynamic changes.
52. Mesoscopic Calcium Imaging (NOT miniscope)
Widefield mesoscopic Ca^{2+} imaging in vivo (distinct from fiber photometry).
53. Adaptive Optics for In Vivo Neural Imaging
Corrects deep-tissue optical distortion; rapidly emerging technique.
54. Oblique Plane Microscopy (OPM)
High-resolution, high-speed volumetric imaging for large-scale neural activity monitoring.
55. Multifocal Two-Photon Microscopy
Simultaneous imaging of multiple planes for 3D functional imaging.
56. Line-Scanning Temporal Focusing Microscopy
High-speed volumetric imaging with reduced out-of-focus excitation.
57. Light Field Microscopy
Captures volumetric data in a single exposure for fast 3D neural activity imaging.
58. Kilohertz Two-Photon Fluorescence Microscopy
Ultrafast scanning rates for capturing rapid neuronal dynamics in vivo.
59. NIRE Cranial Window Method
Uses nanosheet-resin windows for large-scale, chronic high-resolution imaging in
60. Volumetric Fluorescence Lifetime Imaging Microscopy (FLIM) for In Vivo Metabolic Readouts
High-speed volumetric FLIM approaches enabling in vivo mapping of metabolic state (NADH, FAD) and oxygen-consumption dynamics across populations of cells.
61. [NEW] TIRF Microscopy In Vivo
Total internal reflection fluorescence microscopy adapted for superficial cortical imaging in live animals.
62. [NEW] Random Access Microscopy
Acousto-optic deflector-based rapid laser positioning for imaging distributed neurons.
63. [NEW] Reflectance Imaging
Measures intrinsic optical signals from cortical surface without exogenous labels.

64. [NEW] Second Harmonic Generation (SHG) Microscopy

Label-free imaging of membrane potential and structural proteins in live tissue.

E. Optical Indicators / Novel Sensors

65. Genetically Encoded Dopamine Indicators (GRAB-DA, dLight1)

Used widely in vivo with fiber photometry and two-photon microscopy.

66. Genetically Encoded Glutamate Indicators (IGluSnFR)

High temporal resolution; used to study excitatory transmission.

67. Genetically Encoded Acetylcholine Indicators (GAcH)

Maps cholinergic dynamics in vivo.

68. Genetically Encoded cAMP/PKA/Second-Messenger Sensors

(e.g., Pink Flamingo, G-Flamp) reflect intracellular signaling during neural activity.

69. Genetically Encoded Serotonin Sensors (GRAB5-HT)

Monitor serotonergic transmission in behaving animals.

70. Genetically Encoded Norepinephrine Sensors (GRAB-NE)

Track noradrenergic activity during behavior and cognitive tasks.

71. Fluorescent False Neurotransmitters (FFNs)

Visualize neurotransmitter release and recycling in vivo.

72. Genetically Encoded Chloride Indicators (Cl-Sensor)

Monitor chloride dynamics relevant for inhibitory transmission.

73. Genetically Encoded ATP Indicators (IATPSnFR)

Track cellular energy status and metabolic activity in neurons.

74. Genetically Encoded Lactate Sensors

Monitor lactate shuttling and metabolic coupling between neurons and glia.

75. Genetically Encoded Redox Indicators (roGFP)

Detect oxidative stress and redox-state changes during neural activity.

76. Genetically Encoded Nitric Oxide Sensors (geNOps and related probes)

Fluorescent genetically encoded reporters for nitric oxide dynamics to monitor NO signaling in vivo during neural activity.

77. [NEW] Genetically Encoded Potassium Indicators (GEPIs)

Fluorescent sensors for monitoring potassium dynamics in extracellular space.

78. [NEW] pHluorins (pH-sensitive GFPs)

pH-sensitive fluorescent proteins for tracking synaptic vesicle recycling.

79. [NEW] SypHy

Synaptophysin-pHluorin fusion protein for imaging synaptic vesicle exocytosis.

80. [NEW] GCamp Variants (GCamp6f, GCamp7f, GCamp8)

Successive generations of genetically encoded calcium indicators with improved kinetics and sensitivity.

F. Photoacoustic & Hybrid Techniques

81. **Voltage-Sensitive Photoacoustic Imaging**
A new area combining voltage dyes with photoacoustics.
 82. **Nanodiamond Magnetometry in Vivo**
Nitrogen-vacancy (NV) diamond sensors used for in vivo magnetic-field measurements of neuronal activity.
 83. **Multispectral Optoacoustic Tomography (MSOT)**
Provides spectral unmixing of multiple chromophores for functional brain imaging.
 84. **Photoacoustic Computed Tomography (PACT)**
Deep-tissue functional imaging with optical contrast and ultrasound resolution.
 85. **Functional Photoacoustic Microscopy (fPAM)**
High-resolution imaging of hemodynamic responses to neural activity.
 86. **Photoacoustic Lifetime Imaging Microscopy (PALM)**
Measures oxygen consumption and metabolic rates in brain tissue.
 87. **Microbubble-Enhanced Functional Ultrasound (Contrast-Enhanced fUS)**
Use of intravascular microbubble contrast agents to boost sensitivity and spatial resolution of functional ultrasound hemodynamic measurements linked to neural activity.
 88. **[NEW] Photoacoustic Neurotransmitter Sensing**
Molecular imaging of neurotransmitter release using photoacoustic contrast agents.
 89. **[NEW] Granger Causality Photoacoustic Imaging**
Combines photoacoustic imaging with Granger causality analysis for functional connectivity mapping.
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G. Neural Activity Through Blood Flow & Oxygenation

90. **Thermal Infrared Functional Imaging (ITIRI)**
Detects activity-induced microvascular heating.
91. **Speckle-Modulated Optical Coherence Tomography (OCT)**
OCT-based neuronal activity mapping (beyond standard laser speckle imaging).
92. **Doppler Optical Coherence Tomography (D-OCT)**
For real-time blood-flow-linked neural-activity measurements.
93. **Visible Light Optical Coherence Tomography (vis-OCT)**
Provides oximetry and flow measurements with higher resolution than NIR-OCT.
94. **Hyperspectral Imaging of Intrinsic Signals**
Spectral unmixing of hemoglobin, cytochrome oxidase, and other chromophores.
95. **Time-Domain Near-Infrared Spectroscopy (TD-NIRS)**
Offers depth-resolved hemodynamic monitoring with improved accuracy.
96. **Functional Diffuse Optical Tomography (fDOT)**
3D reconstruction of brain activation through light scattering and absorption.
97. **In Vivo Electron Paramagnetic Resonance (EPR) Oximetry**
Direct in vivo EPR/Electron Spin Resonance oximetry for quantitative tissue pO₂ mapping and dynamic oxygen-consumption measurements coupled to neural activity.

98. **[NEW] Laser Doppler Flowmetry**
Continuous measurement of cerebral blood flow using laser Doppler shifts.
 99. **[NEW] Oxygen-15 Water PET ($[^{15}\text{O}]\text{H}_2\text{O}$ PET)**
Gold standard for quantitative cerebral blood flow measurement using positron emission tomography.
 100. **[NEW] Hydrogen Clearance CBF Measurement**
Historical method using hydrogen electrodes to measure local cerebral blood flow.
 101. **[NEW] Autoradiographic CBF Measurement ($[^{14}\text{C}]\text{iodoantipyrine}$)**
Ex vivo quantitative mapping of cerebral blood flow using radiotracers.
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H. Behavioral + Neural Integrated Techniques

102. **Neuromorphic Cameras Linked With Neural Imaging**
High-speed event-driven sensors capturing animal behavior synchronized with brain activity (not a brain technique per se, but part of modern *in vivo* pipelines).
 103. **Deep Label-Free Microscopy (DLFM)**
Uses deep learning to extract neural activity from label-free imaging of scattering changes.
 104. **Acoustic Recording of Neural-Related Behavior**
Ultrasonic vocalization recording synchronized with neural activity measurements.
 105. **Eye-Tracking Integrated Neural Recording**
Combines pupil tracking with brain activity to study visual attention and processing.
 106. **Pose Estimation with Neural-Activity Synchronization**
Uses AI-based body tracking (e.g., DeepLabCut) linked to real-time neural signals.
 107. **Real-Time Closed-Loop Neural Decoding & Stimulation Systems**
Integrated pipelines that decode ongoing neural activity in real time and deliver contingent stimulation (optogenetic, electrical, ultrasonic) to probe causality during behavior.
 108. **[NEW] Whisker Tracking with Neural Recording**
High-speed videography of whisker movements synchronized with neural data.
 109. **[NEW] Operant Conditioning Chambers with Neural Interfaces**
Behavioral boxes integrated with neural recording/stimulation for learning studies.
 110. **[NEW] Sleep-Wake Monitoring with EEG/EMG**
Polysomnography combined with neural activity measurements across sleep stages.
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I. Interference / Modulation Techniques

111. **Focused Ultrasound Blood–Brain Barrier Opening (FUS-BBBO)**
Used *in vivo* to modulate circuits or allow entry of neuromodulators.

112. **Temporal Interference Stimulation (TI Stimulation)**
Non-invasive deep-brain electromagnetic stimulation using intersecting high-frequency currents.
 113. **Transcranial Random Noise Stimulation (RNS)**
Another electrical non-invasive modulation technique widely used.
 114. **Photothermal Neuromodulation (non-genetic)**
Uses nanoparticles or infrared light to activate neurons.
 115. **Infrared Neural Stimulation (INS)**
Pulsed IR light drives neural activity—distinct from optogenetics.
 116. **Scanning Ultrasound Neuromodulation (SUN)**
Focused ultrasound for precise spatiotemporal neural control.
 117. **Optoacoustic Neuromodulation**
Uses laser-generated ultrasound for deep-brain stimulation.
 118. **Ion-CeMST (Ion Current–Controlled Microfluidic Stimulation)**
Microfluidic-based chemical stimulation with spatiotemporal precision.
 119. **Transcranial Photobiomodulation (tPBM)**
Low-level near-infrared light to modulate brain metabolism and activity.
 120. **Vagus Nerve Stimulation (VNS)**
Electrical stimulation of vagus nerve to indirectly influence brain circuits.
 121. **Deep Transcranial Magnetic Stimulation (dTMS)**
Uses H-coil for deeper penetration than standard TMS.
 122. **Closed-Loop Responsive Neurostimulation (RNS) for Research**
Implantable or external systems that detect electrophysiological biomarkers and
 123. **[NEW] Chemical-Genetic Actuation (PSAM/PSEM)**
Pharmacologically selective actuator modules for remote neural control.
 124. **[NEW] Cortical Cooling**
Focal cooling for reversible neural inactivation to study functional localization.
 125. **[NEW] Lidocaine Inactivation**
Local pharmacological blockade of neural activity for connectivity mapping.
 126. **[NEW] Muscimol Inactivation**
GABA_A receptor agonist for reversible cortical silencing in behavioral studies.
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J. Emerging & Frontier Approaches

127. **Bioluminescent Voltage Imaging (e.g., LOTUS-V)**
No excitation light; extremely low phototoxicity for *in vivo* activity imaging.
128. **Upconversion Nanoparticle-Based Neural Imaging**
Allows deeper brain optical readout using NIR-to-visible conversion.
129. **Magnetothermal Neural Recording & Readout**
Not just thermogenetic stimulation—actual readout emerging via nanomaterials.
130. **Molecular fMRI (m-fMRI)**
Probes coupling specific cellular signaling events to MRI contrast.
131. **Functional Ultrasound Localization Microscopy (ULM-fUS)**
Super-resolution vascular mapping during activity.

132. **"Neuromodulation via Magnetic Nanodiscs"**
A newer mechanogenetic-like frontier method.
133. **Quantum Diamond Microscopy**
Uses NV centers for magnetic imaging of neural activity at nanoscale.
134. **X-ray-Induced Acoustic Computed Tomography (XACT)**
Combines X-ray absorption with ultrasound detection for functional imaging.
135. **Magnetic Resonance Spectroscopic Imaging (MRSI)**
Spatially resolved spectroscopy for mapping neurotransmitter distributions.
136. **Neutron Stimulated Emission Computed Tomography (NSECT)**
Emerging nuclear technique for elemental mapping of neural tissue.
137. **Holographic Optogenetic Stimulation**
Uses holography for multi-site optical neural control and readout.
138. **Nanowire Intracellular Recordings**
Nanoscale wires for minimally invasive intracellular potential measurements.
139. **AI-Augmented Functional Connectivity Analysis**
Machine-learning-enhanced mapping of dynamic brain networks from imaging data.
140. **Cryogenic Electron Microscopy for In Vivo Snapshots**
Adapted for rapid freezing and imaging of activity states (though borderline *in vivo*).
141. **In Vivo Quantum Diamond Scalp Magnetometry (NV-MEG)**
Scalp-mounted or near-scalp arrays of diamond NV sensors for high-spatial-resolution magnetic field mapping of population neural currents, bridging nanoscale NV sensing advances with whole-head MEG-style recordings.
142. **[NEW] CLARITY with In Vivo Applications**
Tissue transformation for post-mortem structural mapping of functionally identified circuits.
143. **[NEW] Expansion Microscopy In Vivo**
Physical tissue expansion for super-resolution imaging of activated circuits.
144. **[NEW] Magnetic Resonance Phased Array Microscopy**
Ultra-high field MRI with phased array coils for microscopic resolution in live animals.
145. **[NEW] X-ray Optogenetics**
Combining X-ray stimulation with optogenetic actuators for deep brain modulation.
146. **[NEW] Neutron Scattering Tomography**
Emerging technique for mapping light element distributions in neural tissue.
147. **[NEW] Diamond Quantum Sensing of Neural Magnetic Fields**
NV center magnetometry for direct detection of action potentials and synaptic currents.