

LIST OF NEUROSCIENCE TECHNIQUES TO STUDY BRAIN ACTIVITY IN VIVO

Following the first step, a further refining of the list is used by verifying the general reviews -- also listed afterwards, together with their contributions.

[I] = Invasive [NI] = Non-Invasive

Magnetic Resonance & Computed Tomography (CT) Imaging Techniques

Functional Magnetic Resonance Imaging [NI]

1. Blood Oxygen Dependent Levels (BOLD) [NI]
2. quantitative MRI (qMRI) for Manganese (Mn) and Iron (Fe) [NI]
3. Dynamic Susceptibility Contrast (DSC)-MRI [NI]
4. Arterial Spin Labeling (ASL) [NI]
5. Nuclear Magnetic Resonance Spectroscopy [NI]
 - 13C Magnetic Resonance Spectroscopy
6. Diffusion-weighted MRI (DW-MRI) [NI]
7. Diffusion Tensor Imaging MRI (DTI) [NI]
8. Positron Emission Tomography (PET) [NI]
 - Assay of Enzyme Activity, Neuroreceptors/Neurotransporters, Messenger Pathways
 - Quantification of Cerebral Blood Flow
9. Single-Photon Emission Computerized Tomography [NI]
10. Cerebral Blood Flow with Stable Xenon CT [NI]

Ultrasound

11. Transcranial Doppler [NI]
 - Functional Ultrasound (fUS) [NI]

EEG & MEG

12. Electroencephalography [NI]
 - High-density EEG
13. Electrocorticogram and microelectrocorticogram [I]
14. Magnetoencephalography [NI]

INVASIVE ELECTRICAL RECORDINGS

15. Stentrode [I]
16. Neural Dust [I]
17. Deep Brain Stimulation [I]
18. Single Electrodes [I]
19. Multielectrode Array [I]

CELLULAR RECORDINGS / PATCH-CLAMP

20. Patch-Clamp Techniques [I]

Voltage-Clamp Fluorometry *[I]*
Patch-Clamp Fluorometry *[I]*

MICROSCOPY / MICROENDOSCOPY

- 21. One-Photon Microscopy *[I]*
 - GRIN LENSES
 - Miniscopes
 - mini-mScope Mesoscale Calcium (Ca⁺⁺)
- 22. Two-Photon Microscopy *[I]*
- 23. Three-Photon Microscopy *[I]*
- 24. Fiber Photometry *[I]*
- 25. High-Density Multichannel Fiber Photometry *[I]*
- 26. Neuro-FITM *[I]*
- 27. Wide-Field Fluorescence Imaging
- 28. Confocal Fluorescence Imaging

NEUROSENSING / ELECTROCHEMICAL

- 29. Microdialysis *[I]*
 - High Performance Liquid Chromatography (HPLC)
 - Capillary Electrophoresis (CE)
 - Mass Spectrometry (MS)
 - Electrochemical Workstations
- 30. Column Liquid Chromatography *[I]*
- 31. Push–Pull Superfusion Technique (PPST) *[I]*
- Carbon Electrode Surface Chemistry *[I]*
- 32. Voltammetry *[I]*
 - Differential Pulse Voltammetry (DPV)
 - Cyclic Voltammetry (CV)
 - Fast-Scan Cyclic Voltammetry (FSCV)
- 33. Amperometry *[I]*
 - High-Speed Chronoamperometry
- 34. Neurotransmitter/Neuropeptide Sensors *[I]*
 - Periplasmic Binding Protein (PBP)-based sensors
 - G-protein coupled receptor (GPCR)-based sensors
- 36. Electrochemical Aptamer Based Sensors *[I]*
- 37. Molecularly Imprinted Polymers (MIPs) *[I]*
- 38. Enzyme-based Sensor *[I]*
- 39. Liquid Liquid Interface Microsensor (LLIM) *[I]*

FLUORESCENCE & RAMAN SPECTROSCOPY

- 40. Fluorescence Spectroscopy *[I]*
- 41. Raman Spectroscopy *[I]*

FLUORESCENT ACTIVITY INDICATORS

DYES AND ENCODING

- 42. Voltage-sensitive dye imaging (VSDI) (Ratiometric / Nonratiometric) [I]
- 43. Calcium Indicator Dyes (Ratiometric / Nonratiometric) [I]
 - Fluorescent Calcium Indicators Dyes
 - acetoxymethyl (AM) ester-based Multi Cell Bolus Loading (MCBL)
- 44. Genetically Encoded Voltage Indicators (GEVIs) [I]
 - Genetically Encoded Ca⁺⁺ Indicators (GECIs)
 - GCaMP
 - Sensitive Bioluminescence Reporter
- 45. pH-sensitive Fluorescent Proteins [I]

FLUORESCENCE READOUT TECHNIQUES

- 46. Fluorescence/Föster Resonance Energy Transfer (FRET) [I]
- 47. Bimolecular Fluorescence Complementation (BiFC) [I]
- 48. Fluorescence Recovery After Photobleaching (FRAP) [I]
- 49. Photoactivation/Photoconversion [I]
- 50. Phosphorescence Lifetime (PLIM) [I]
- 51. Multiphoton FRET-FLIM [I]

OPTICAL APPROACHES

- 52. Diffuse Optical Imaging [NI]
- 53. Near Infrared Spectroscopy [NI]
- 54. Intrinsic Optical Imaging [I/NI]
- 55. Laser Speckle Contrast Imaging [I/NI]

PHOTOACOUSTIC

- 56. Photoacoustic Imaging (PAI) [I/NI]
 - Photoacoustic Microscopy (PAM) [I]
 - Photoacoustic Tomography (PAT) [NI]

ACTIVITY TAGGING

- 57. CaMPARI

INTERFERENCE

ELECTRICAL/MAGNETIC

- 58. Transcranial Magnetic Stimulation [NI]
- 59. Transcranial Direct Current Stimulation (tDCS) [NI]
- 60. Transcranial Alternating Current Stimulation (tACS) [NI]
- 61. Microstimulation [I]
- 62. Electrolytic lesions [I]

EXCLUSIVELY GENETIC

- 63. Transgenes from other species [I]
- 64. Chemogenetics
 - Designer receptors exclusively activated by designer drugs (DREADDs: hM3Dq, hM4Di) [I]
- 65. RNA Interference (RNAi) [I]
- 66. Morpholinos [I]

67. Dominant Negatives [I]

68. Single-Cell Electroporation (SCE) (Is an Interference Technique) [I]

OPTOGENETICS AND GENETICALLY MEDIATED DERIVATIVES

69. Optogenetics [I]

Channelrhodopsin-2 (ChR2)

Halorhodopsin (NpHR)

Archaeorhodopsin (Arch)

Anion-conducting channelrhodopsins (ACRs)

Photoswitchable Voltage-Gated Ion Channels

Photoswitchable Ligand-Gated Ion Channels

Optical Switch Protein Conjugates

70. Magnetogenetic Stimulation [I]

71. Thermogenetic Stimulation [I]

72. Mechanogenetic Stimulation [I]

ULTRASOUND

73. Ultrasonic Neuromodulation [NI]

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1. **Behind the scenes of functional brain imaging: A historical and physiological perspective (1998)**

<https://www.pnas.org/doi/10.1073/pnas.95.3.765>

Helped to situate the state of the art at the time, no additions or exclusions;

2. **Exploring the Frontiers of Neuroimaging: A Review of Recent Advances in Understanding Brain Functioning and Disorders**

<https://doi.org/10.3390/life13071472>

Added DW-MRI, DTI and tDCS

3. **Emerging imaging methods to study whole-brain function in rodent models**

<https://doi.org/10.1038/s41398-021-01575-5>

Added functional Ultrasound (fUS), Intrinsic Optical Imaging (IOI), Laser Speckle Contrast Imaging (LSCI), Photoacoustic Imaging (PAI), Photoacoustic Microscopy (PAM), Photoacoustic Tomography (PAT)

4. **Advancements in the Quest to Map, Monitor, and Manipulate Neural Circuitry**

<https://doi.org/10.3389/fncir.2022.886302>

Added CaMPARI (other tagging techniques require post-mortem analysis), Neurotransmitter/Neuropeptide Sensors (periplasmic binding protein (PBP)-based sensors and G-protein coupled receptor (GPCR)-based sensors)

5. Real-Time Monitoring of Neurotransmitters in the Brain of Living Animals

<https://doi.org/10.1021/acsami.2c02740>

Added: Differential Pulse Voltammetry (DPV), Cyclic Voltammetry (CV), Electrochemical Aptamer Based Sensors, Enzyme-based Sensors, Molecularly Imprinted Polymers (MIPs), Liq./Liq. Interface Microsensor (LLIM), Fluorescence Spectroscopy, Raman Spectroscopy.

And specifying biochemical analysis for Microdialysis, i.e., High Performance Liquid Chromatography (HPLC), Capillary Electrophoresis (CE), Mass Spectrometry (MS), Electrochemical Workstations.

6. The origin of Extracellular Fields and Currents - EEG, ECoG, LFP, Spikes

<https://doi.org/10.1038/nrn3241>

Added Electrocorticogram (ECoG)

7. In Vivo Imaging of Neural Activity

<https://doi.org/10.1038/nmeth.4230>

Added Three-Photon Microscopy, and helped to contextualize all the microscopy techniques;

8. Defining Surgical Terminology and Risk for Brain Computer Interface Technologies

<https://doi.org/10.3389/fnins.2021.599549>

Added Stentrode, Neural Dust

9. Genetics-Based Targeting Strategies for Precise Neuromodulation

<https://doi.org/10.1002/advs.202413817>

Added Thermogenetic and Mechanogenetic techniques;