

Microelectrode electrophysiology: Extending the Brain Imaging Data Structure to intracellular and extracellular recordings in animal models

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ABSTRACT

The Brain Imaging Data Structure (BIDS) has facilitated data sharing and tool development in human neuroimaging. We present an extension for microelectrode electrophysiology recordings in animal models, addressing the unique requirements of intracellular and extracellular recordings. This extension introduces two new data types: 'icephys' for intracellular and 'ecephys' for extracellular recordings, supporting diverse recording modalities from patch-clamp to high-density silicon probes. Building on existing BIDS principles and prior electrophysiology extensions, we specify metadata for probes, electrodes, and channels, with particular attention to metadata required for spike sorting analysis. The extension adopts NWB (Neurodata Without Borders) and NIX (Neuroscience Information Exchange) as data formats, ensuring comprehensive metadata capture while maintaining compatibility with existing analysis ecosystems. We provide example datasets covering common use cases and demonstrate integration with established tools including [Which tools?]. This standardization enables reproducible analysis pipelines, facilitates data sharing through repositories like DANDI, G-Node and EBRAINS, and bridges scales from cellular to systems neuroscience.

Background & Summary

Microelectrode electrophysiology encompasses techniques for recording electrical activity from individual neurons to local field potentials, providing crucial insights into neural computation. Recent technological advances, including high-density silicon probes and standardized probe designs through the Neuropixels project, have dramatically increased data acquisition rates and experimental complexity.

While comprehensive data formats exist for neurophysiology (NWB; NIX), the field lacks standardized organization principles for datasets, metadata specifications, and directory structures. This fragmentation impedes data sharing, with surveys indicating [ADD SURVEY DATA] of researchers struggling to share or reuse electrophysiology data due to inconsistent formats and missing metadata.

BIDS has successfully standardized human neuroimaging data organization [cite], with over 850 datasets on OpenNeuro [cite] and adoption by major repositories. Prior BIDS extensions for human electrophysiology (EEG [cite], MEG [cite], iEEG [cite]) established patterns for organizing time-series neural data, while the Microscopy extension [cite] introduced critical metadata fields for animal data.

Microelectrode recordings present unique challenges: (1) electrode scales spanning orders of magnitude (sub-micron tips to millimeter arrays), (2) diverse probe geometries requiring specialized coordinate systems, (3) spike sorting as an essential preprocessing step requires specific metadata,

Here we present BEP032, extending BIDS to microelectrode electrophysiology, with a focus on animal models. This extension: [summarize key contributions]

Methods

Community Development Process

The development of BEP032 began in [DATE] through the INCF Working Group on Standardized Data Structures.

Scope and Design Principles

Inclusion Criteria

Design Decisions

The division between intracellular (icephys) and extracellular (ecephys) electrophysiology is based on the recording techniques and the resulting data characteristics. Icephys typically involves high-resolution recordings from individual neurons, requiring detailed metadata about the cell type, location, and experimental conditions. In contrast, ecephys captures broader population activity, necessitating metadata that describes the electrode array configuration, spatial sampling, and signal processing methods.

35 **Data Format Specification**
36 **Supported Formats**
37 *Data Stream Linking*
38 **Directory Structure and File Organization**
39 *Data Type Specification*
40 *Required and Optional Files*
41 **Metadata Specifications**
42 *Inheritance Principle*
43 *Required Metadata Fields*
44 *Animal-Specific Metadata*
45 **Probe, Electrode, and Channel Specifications**
46 *Probes TSV Specification*
47 *ProbeInterface Integration*
48 *Electrodes TSV Specification*
49 *Channels TSV Specification*
50 **Coordinate Systems**
51 *Dual Coordinate Approach*
52 *Probe-Relative Coordinates*
53 *Surgical Coordinate Conventions*
54 *Brain Atlas Integration*
55 **Spike Sorting and Derivatives**
56 **Integration with Existing Tools**
57 *Conversion Tools*
58 *Analysis Pipelines*
59 **Data Records**

60 Example datasets demonstrating the specification are available at [REPOSITORY].

61 **Dataset 1: One icephys dataset**
62 **Dataset 2: One chronic ecephys dataset**
63 **Dataset 3: One acute ecephys experiment**
64 **Dataset 4: Neuropixels Multi-Region Recording**
65 **Technical Validation**

66 **Validator Compliance**
67 **Round-Trip Conversion**
68 **Cross-Tool Compatibility**
69 **File Size and Performance**
70 **Usage Notes**

71 **Converting Existing Data**
72 **Recommended Workflows**
73 **Integration with Other Modalities**
74 **Repository Submission**
75 **Code availability**

76 BEP032tools [VERSION] provides validation and conversion utilities: [GITHUB LINK] Example conversion scripts are
77 available at: [GITHUB LINK] The specification is maintained at: <https://github.com/bids-standard/bids-specification>

78 **References**

79 **Acknowledgements**

80 **Author Contributions**

81 **Competing Interests**

82 The authors declare no competing interests.

83 **Figures & Tables**

Figure 1. Overview of the BIDS microelectrode electrophysiology extension showing an example extracellular electrophysiology dataset. Left: directory structure with the `ecophys` / `datatype` folder containing data files and metadata. Right: file contents showing (a) the sidecar JSON with recording metadata, (b) `probes.tsv` describing probe placement and type, (c) `electrodes.tsv` with probe-relative electrode positions, (d) `channels.tsv` linking recorded signals to electrodes, and (e) example voltage traces. Numbered labels connect files in the directory tree to their content panels.