

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, 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]

Microphys-BIDS Summary

Specific Microphys-BIDS Considerations

Probes, Electrodes, and Channels

The iEEG-BIDS and EEG-BIDS extensions distinguished electrodes from channels: an electrode is a contact point with tissue, a channel is the amplifier and digitizer that produces a stored time series. These are not equivalent, a differential recording derives one channel from two electrodes, a Neuropixels electrode may yield separate highpass and LFP channels at different sampling rates, and a sync signal is a channel with no electrode at all. The prior extensions noted that electrodes can be “organized into arrays, grids, or probes,” but their metadata captured only electrodes and channels, not this grouping.

We add an explicit probe level. A probe is the physical device, Neuropixels, tetrode bundle, patch pipette, carrying one or more electrodes. This matters because probe-level metadata (manufacturer, surgical coordinates, insertion angle) applies to all electrodes on that probe, while electrode-level metadata (position, impedance) defines the geometry, and channel-level metadata (gain, filters) describes the acquisition.

36 Three files capture this. `probes.tsv` lists each probe with its type and surgical placement. `electrodes.tsv`
37 enumerates contact sites, linking each to its probe and specifying probe-relative coordinates for spike sorting. `channels.tsv`
38 documents recorded signals: sampling frequency, units, source electrode, and reference. Channels without electrodes (sync,
39 stimulus) use n/a; ground, typically hardware like a skull screw or ear clip, is defined globally in the sidecar JSON and can be
40 overridden per-channel if it differs. A `stream_id` column links channels to data objects within the NWB or NIX file.

41 **Intracellular vs Extracellular Datatypes**

42 **Coordinate Systems**

43 **Data Format Requirements**

44 **ProbeInterface Integration**

45 **Software and Tools**

46 **Data Records**

47 **Technical Validation**

48 **Usage Notes**

49 **Code Availability**

50 **References**

51 **Acknowledgements**

52 **Author Contributions**

53 **Competing Interests**

54 The authors declare no competing interests.

55 **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.