BIDS: The Brain Imaging Data Standard
A data standard to support the neuroimaging community

LAY SUMMARY

The Brain Imaging Data Structure (BIDS, www.bids-standard.org) is a community-led standard for organizing, describing and sharing neuroimaging data. Currently, it supports multiple neuroimaging modalities including MRI, MEG, EEG, iEEG, with more to come. Multiple applications and tools have been released to make it easy for researchers to incorporate BIDS into their current workflows, maximising reproducibility, enabling effective data sharing, and supporting good data management practices.

RATIONALE

Why is BIDS needed?

Neuroimaging experiments result in complicated data that can be arranged in many different ways. Historically, data were organized differently between institutions and even within a lab. This lack of consensus (or a standard) led to misunderstandings and suboptimal usage of resources: 1) human (time wasted on rearranging data or rewriting scripts expecting certain structure; 2) infrastructure (data storage space); 3) financial (disorganized data has limited longevity and value after first publication). Finally, it produces poor reproducibility of results, even within the lab where data were collected. The Brain Imaging Data Structure (BIDS) has provided the neuroimaging community with a simple and easily adopted way of organizing neuroimaging data.

What is BIDS?

The Brain Imaging Data Structure (BIDS) is a community-led standard for organizing, describing and sharing neuroimaging data. Its goal is to make neuroimaging data more accessible, shareable, and usable by researchers. To achieve this goal, BIDS provides a simple and intuitive way to organize and describe neuroimaging data and associated data and metadata. BIDS is based on simple file formats (often text-based) and folder structures that can easily be adopted by any researcher around the world with minimum effort. BIDS is not a file format, but instead relies upon common standard file formats (e.g. nifti, json, tsv). BIDS has two major components. First, it specifies a naming convention for files and directories. Second, it specifies conventions for the organization of metadata. A robust validator allows researchers to easily check whether a dataset meets the standard.

Key to success

BIDS has three foundational principles: 1) to minimize complexity and facilitate adoption, reuse existing methods and technologies whenever possible; 2) tackle the most commonly used neuroimaging data, derivatives, and models (inspired by the Pareto principle); 3) enabling and maximizing community engagement in the creation and extension of the specification, to ensure maximal adoption by the research community.

SIGNIFICANCE

Benefits of BIDS

1) Efficient data usage: The use of a common format allows data to be more easily reused by other researchers, maximizing its utility. 2) Analysis pipelines: there is a growing number of data analysis software packages (BIDS-Apps) that can automatically process data organized according to BIDS; 3) Data sharing: Use of BIDS makes sharing by major repositories (e.g. OpenNeuro) very simple, enabling rapid and effective data sharing.

BIDS neuroimaging modalities currently supported

The BIDS standard was first established for MRI and fMRI in 2015 (Gorgolewski et al. 2016). BIDS is based on simple file formats (often text-based) and folder structures that can readily expand to additional data modalities. BIDS was heavily inspired by the format used internally by the OpenfMRI repository that is now known as OpenNeuro. Following the initial success of MRI BIDS and associated BIDS Apps, there was a clear need for extensions into other modalities. In 2016, an international consortium proposed an extension of BIDS for Magnetoencephalography (MEG) datasets (Niso et al. 2018). The MEG-BIDS extension highly contributed to further extend BIDS to other electrophysiological data modalities. The electroencephalography (EEG) extension (Pernet et al. 2019) and the intracranial EEG (iEEG) extension (Holdgraf et al. 2019) were soon released. Currently, there are 24 active extension proposals spanning several imaging modalities, derivative products, and data types (represented in Tables 1 and 2). We are

Table 1. BIDS Extension Proposals
Merged into the main BIDS Specification

BEP	Title
BEP003	Common Derivatives
BEP006	Electroencephalography (EEG)
BEP007	Hierarchical Event Descriptor (HED) Tags
BEP008	Magnetoencephalography (MEG)
BEP010	intracranial Electroencephalography (iEEG)
BEP018	Genetic information

Table 2. BIDS Extension Proposals
Currently active

BEP	Title
BEP001	Structural with multiple contrasts
BEP002	Models
BEP004	Susceptibility Weighted Imaging (SWI)
BEP005	Arterial Spin Labeling (ASL)
BEP009	Positron Emission Tomography (PET)
BEP011	Structural preprocessing derivatives
BEP012	Functional preprocessing derivatives
BEP013	Resting state derivatives
BEP014	Affine transformations & nonlinear warps
BEP016	Diffusion weighted imaging derivatives
BEP017	Generic connectivity data schema
BEP019	DICOM Metadata
BEP020	Eye Tracking (ET)
BEP021	Common Electrophysiological Derivatives
BEP022	Magnetic Resonance Spectroscopy (MRS)
BEP023	PET Preprocessing derivatives
BEP024	Computed Tomography scan (CT)
BEP025	Medical Imaging Data structure (MIDS)
BEP026	Microelectrode Recordings (MER)
BEP027	Execution
BEP028	Provenance
BEP029	Virtual and physical motion data
BEP030	Near Infrared Spectroscopy (NIRS)
BEP031	Microscopy

preparing to accept the Arterial Spin Labeling (ASL) and Positron Emission Tomography (PET) extensions into BIDS.

While working on BIDS we consulted many neuroscientists to make sure it covers most common experiments, but at the same time is intuitive and easy to adopt. The specification is intentionally based on simple file formats and folder structures to reflect common lab practices and make it accessible to a wide range of scientists coming from different backgrounds.

Figure 1. BIDS Organizational Design
It is based on three pillars: standard, tools and collaboration

APPROACH

BIDS is a community effort

BIDS is developed by the community for the community and everybody can become a part of the community.

The BIDS Organizational Design

The BIDS organization is a community of brain researchers that strives for consensus decision making. The BIDS organization primarily produces the BIDS-Specification along with supporting BIDS-aware tools and community. Our organizational design works in tandem with our governance structure to describe the BIDS environment, and it is based on three pillars: 1) **Standard**: related to the BIDS Specification and BIDS Extension Proposals (BEPs); 2) **Tools**: BIDS Apps and BIDS-aware software; and 3) **Collaboration**: BIDS community. Our organizational design is driven by three principles: Sustainability, Robustness, and Inclusivity. See more at: BIDS Organization.

BIDS Governance

To achieve the goals of widespread adoption of the standard while growing to adapt to its community of members, BIDS is led by a series of groups presented in Figure 2. See more at: BIDS Governance.
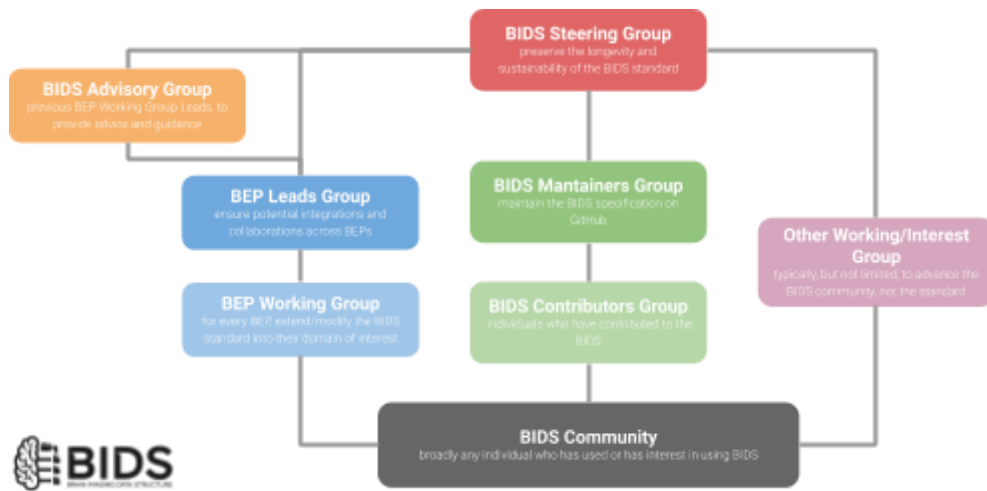
Figure 2. BIDS Governance
BIDS Steering Group, BIDS Advisory Group, BEP Leads Group, BEP Working Group, BIDS Maintainers Group, BIDS Contributors Group, Other Working/Interest Group and BIDS community

Principles for open standards development

The BIDS approach to standards development follows the principles of the [Modern Paradigm for Standards](#) developed by OpenStand: 1) respectful cooperation between standards organizations, 2) adherence to fundamental principles of standards development: due process, broad consensus, transparency, balance, openness, 3) collective empowerment, 4) availability, 5) voluntary adoption.

EVIDENCE OF IMPACT

Since its origin, the BIDS has revolutionized the way in which neuroimaging research is done. BIDS has a community of 136 credited contributors (22 female, as of October 3, 2020) ([link](#)), with ~10,000 users visiting [the website](#), and ~7,000 users exploring the [BIDS Specification](#), over the past 6 months (see Figure 3). We have organized over 100 worldwide educational workshops and presentations at conferences over the last year (see e.g. BIDS presence at [OHBM](#)). Over 404 journal articles have [cited](#) BIDS or any of its extensions. Currently, more than 60 [reported](#) centers, institutes and databases around the world have implemented BIDS as their organizational structure. As of October 7, 2020, we have 196 people signed up for our BIDS email list and 414 members on our google group.
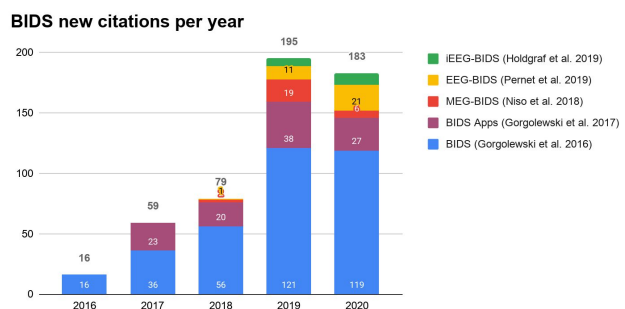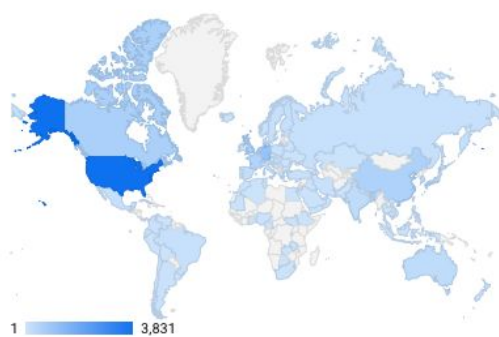
Figure 3. BIDS Impact
Left: World distribution of BIDS users over the past 6 months. Right: BIDS new citations per year (source: Google Scholar)