The management of neuroscience data

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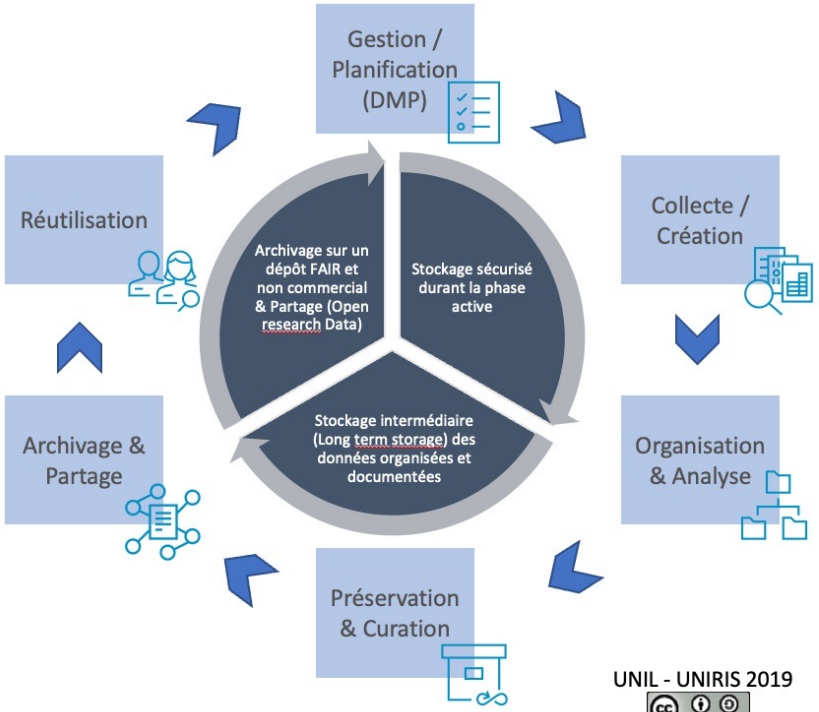
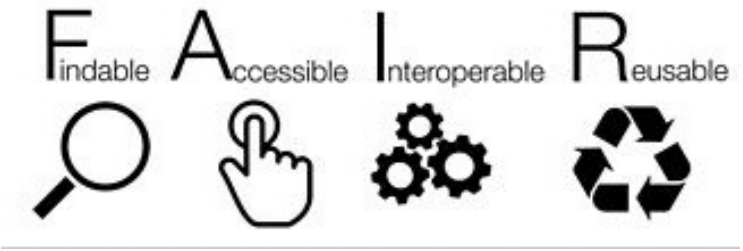
The life cycle of scientific data

Cycle de vie des données de recherche



UNIL - UNIRIS 2019

The FAIR formalism



Findable
The first step in (re)using data is to find them. Metadata and data should be easy to find for both humans and computers. Machine-readable metadata are essential for automatic discovery of datasets and services, so this is an essential component of the FAIRification process.

Accessible
Once the user finds the required data, they need to know how they can be accessed, possibly including authentication and authorisation.

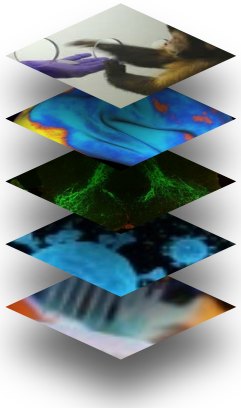
Interoperable
The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing.

Reusable
The ultimate goal of FAIR is to optimise the reuse of data. To achieve this, metadata and data should be well-described so that they can be replicated and/or combined in different settings.

The principles refer to three types of entities: **data** (or any digital object), **metadata** (information about that digital object), and **infrastructure**. For instance, principle F4 defines that both metadata and data are registered or indexed in a searchable resource (the infrastructure component).

Managing data at institute-level: an example

Plateforms



Clinical

Large international databases

Human Connectome

OASIS

C-MIND

Managing data at institute-level: an example

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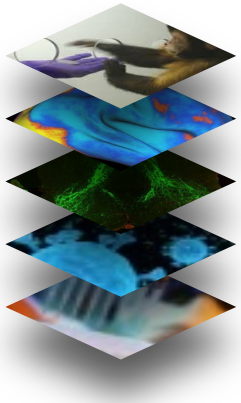

Clinical

Large international databases

MRI neuroimaging
- *Anatomical*
- *Diffusion*
- *Functional*
- *Quantitative*
- *…*

Optical Imaging
- *Bi-photon microscopy*
- *Confocal microscopy*
- *Mesoscopic optical imaging*
- *Spectroscopy*
- *Laser doppler flowmetry*
- *Optical coherence tomography*
- *Histology / tracing*

Electrophysiology
- *EEG/MEG*
- *Multi-electrodes array*
- *SIngle cell recordings*
- *Deep brain stimulation recordings*

NeuroBioTools
- *Genomics*
- *Transcriptomics*

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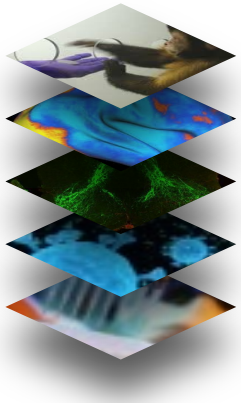

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Mouse

Rat

Marmoset

Macaque

Baboon

Chimpanzee

Human

Microscopic

Mesoscopic

Macroscopic

In Vivo

Post-mortem

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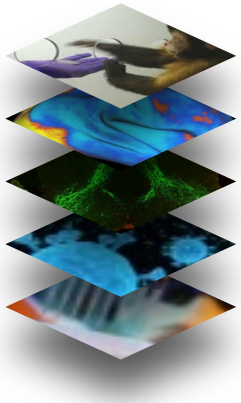

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Heterogeneous data

Multiple sources

Multiple scales

Large quantities (~300To)

Large need of data processing

Findable: where’s my data ?

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« On a portable hard drive. My PhD student has got it. I'll email him»

Non secure and unreliable storage. No backup.

Major risk: Complete data loss
Other risks: loss of associated data and impossibility to reprocess.

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« On a workstation in the experimental room. From time to time I make a copy of the hard drive. »

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« On a (professional level) storage server »

Secure storage, guaranteed backup

Can we find the data, can we proceed to new analyses ?

Rationalizing data magement. Goals and motivations

To eliminate all possibility of data loss

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To offer an easy and reliable access to all data using specifric queries

databasing, indexation

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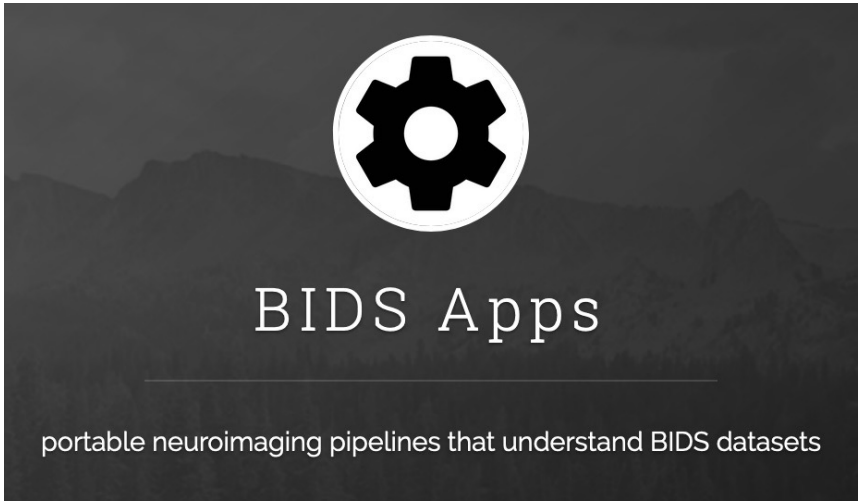
To ease or automate data processing

Formatage / standardisation du stockage



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Reduce costs

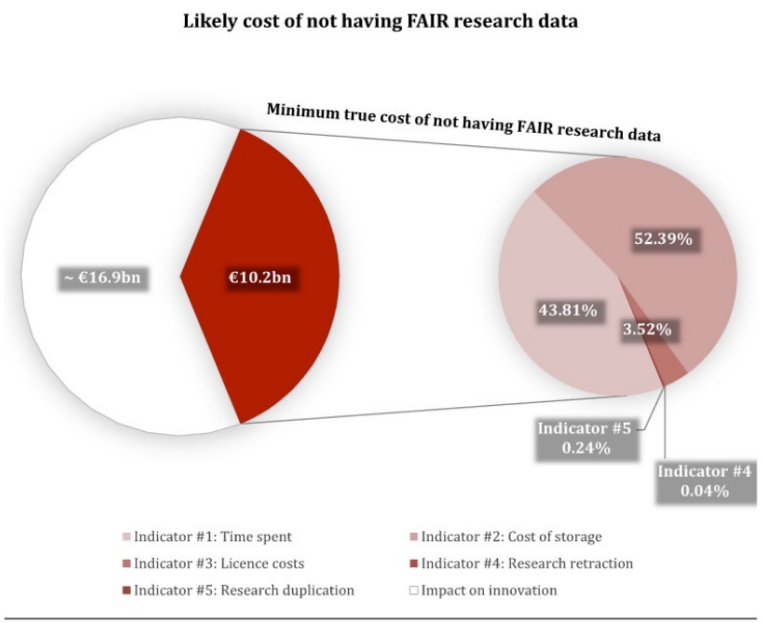

Figure 5: Cost breakdown

« We estimate the annual cost of not having FAIR data to a minimum of €10.2bn per year. The actual cost is likely to be much higher due to unquantifiable elements such a the value of improved research quality and other indirect positive spill-over effects of FAIR research data. »

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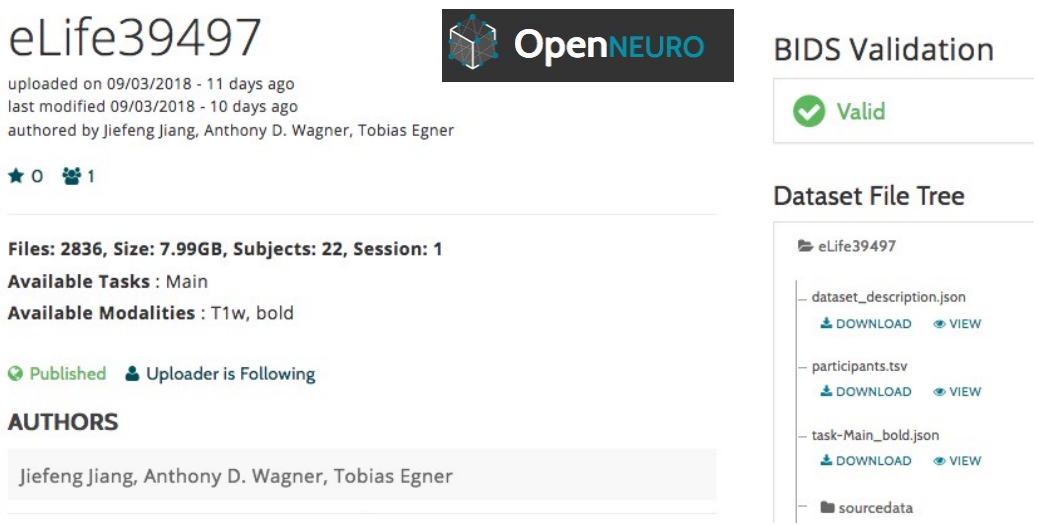
To facilitate data sharing between researchers, and/or journals requiring an access to experimental data

Universal formatting of data



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To propose a Data Management Plan to researchers

Qu'est-ce que le pilote de libre accès aux données de recherche Open Research Data ?

Il s'agit d'une opération pilote tendant à rendre accessible au plus grand nombre d'utilisateurs les données de recherche générées dans des projets financés dans le cadre du programme Horizon 2020.

Les bénéficiaires qui y sont tenus doivent rendre accessibles gratuitement les données de recherche issues des projets financés.

Le Work Programme définit les domaines dans lesquels le pilote est applicable.

De quelles données s'agit-il ?

- données et métadonnées nécessaires à la validation des publications : obligatoire ;
- autres données et métadonnées que le bénéficiaire a choisi de diffuser en accès ouvert : spécifiées dans le plan de gestion des données ou **DMP** - "***Data Management Plan***".

Si certaines données ne pourront être rendues accessibles, cela devra être justifié dans le DMP (risque de compromettre le projet, raisons éthiques, règlementation relative aux données personnelles, propriété intellectuelle, sécurité...).

Où ?

Dans une base de données de recherche - "***research data repository***" - permettant de

Qu'est-ce que le DMP - Data Management Plan ?

- le DMP est un livrable du projet attendu dans les 6 premiers mois de la vie du projet (des améliorations du DMP peuvent également faire l'objet de livrables subséquents) ;
- le DMP est obligatoire dans les projets inscrit au pilote Open Research Data ;
- le DMP décrit comment les données de recherche collectées ou générées seront gérées pendant et après le projet (méthodologie, standards...), quelles données seront partagées ou diffusées en Open Data, mais aussi comment les données seront conservées ;
- le DMP n'est pas contenu dans la proposition de projet soumise et ne fait pas partie de l'évaluation.
  En revanche, dans les actions de recherche et d'innovation (RIA) et et les actions d'innovation (IA) le "***template proposal***" inclut une section management des données de recherches, évaluée sous le critère "impact".

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Accueil > Recherche

RECHERCHE

Le Plan national pour la science ouverte : les résultats de la recherche scientifique ouverts à tous, sans entrave, sans délai, sans paiement

Le Plan national pour la science ouverte annoncé par Frédérique Vidal, le 4 juillet 2018, rend obligatoire l'accès ouvert pour les publications et pour les données issues de recherches financées sur projets. Il met en place un Comité pour la science ouverte et soutient des initiatives majeures de structuration du paysage concernant les publications et les données. Enfin, il est doté d'un volet formation et d'un volet international qui sont essentiels à la mobilisation des communautés scientifiques et à l'influence de la France dans ce paysage en cours de constitution.

Actualité - 1ère publication : 4.07.2018 - Mise à jour : 12.07.2018

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La Plateforme canadienne de neuroscience ouverte (PCNO)

La Plateforme canadienne de neuroscience ouverte (PCNO) a pour mission de mettre en place une plateforme nationale pour le libre échange de données issues de la recherche en neurosciences. Cette plateforme réunit bon nombre des meilleurs chercheurs en neurosciences cliniques et fondamentales, informaticiens et experts en politique scientifique du pays pour former un réseau interactif de collaboration pour la recherche sur le cerveau, l'enseignement interdisciplinaire, les partenariats internationaux, les applications cliniques et la publication ouverte.

La plateforme fournira une interface unifiée à la communauté scientifique et propulsera la recherche canadienne en neurosciences par le partage de données et de méthodes, la création de bases de données à grande échelle, le développement de normes de partage, la facilitation de stratégies d'analyses avancées, la dissémination ouverte de données et de méthodes en neurosciences à la collectivité mondiale et la mise en place de programmes de formation pour la prochaine génération de chercheurs en neurosciences computationnelles. La PCNO vise à éliminer les barrières techniques entravant la science ouverte et à améliorer l'accessibilité et la réutilisabilité de la recherche en neuroscience pour accélérer le rythme auquel les découvertes sont faites.

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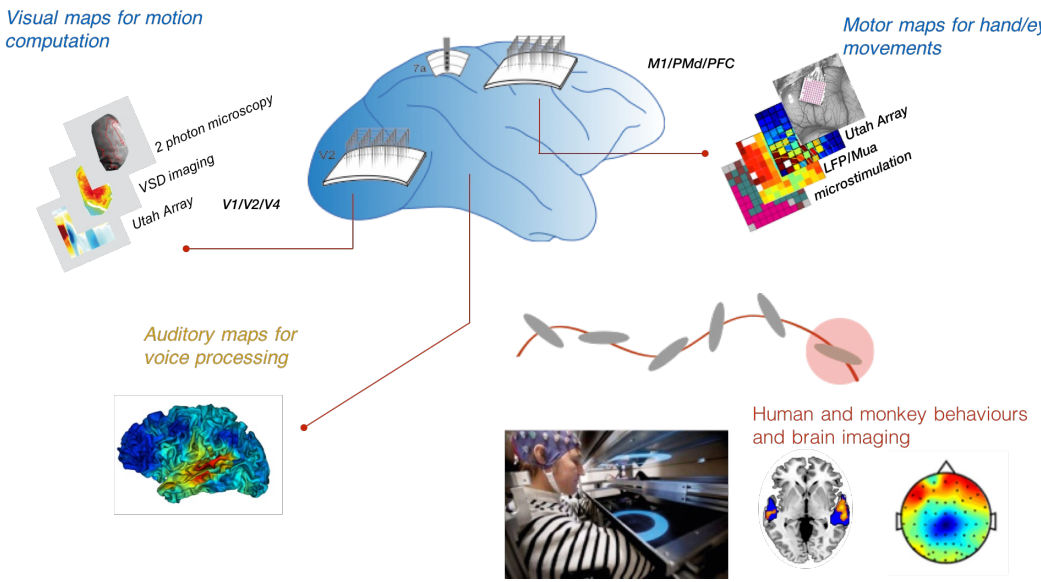
To facilitate scientific projects using heterogeneous multi-modal data, or to facilitate machine learning

Dynamics of cortical maps for decision, action and perception
(Teams: CoMCo, NeOpto, InViBe, BanCO)



The 3 pillars of good data management

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Storage

Must guarantee security and regular data backup

All data must be stored as automatically as possible on storage servers

↓

No loss

The 3 pillars of good data management

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Indexing

Ensures that the data is traceable, and possibly accessible according to specific queries based on descriptive metadata

This indexation is usually performed via a database engine.

Access

The 3 pillars of good data management

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Standardised nomenclature defining storage and organization of data and associated metadata.

Ensures that data can be exchanged and analysed autonomously

Sharing, reproducing, reusing

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Sharing, reproducing, reusing

Automatic processing

Structuring data : the BIDS standard

Standard data structure for MRI data
Open & community based project
Growing ecosystem: Validation, Database integration, BIDS Apps
Extensions for related modalities

- MEG
- EEG
- IEEG
- PET
- Physiological data (respiration, cardiac activity, ...)
- Behavioural data
- Microscopy
- NIRS

BIDS

- BIDS is:
  - organizing data in a folder
  - naming files
  - documenting metadata
  - facilitating re-use by your future self and others

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- BIDS defines a data structure:

```
└── MyProject
    ├── source
    ├── raw
    │   ├── sub-01
    │   │   ├── ses-01
    │   │   │   ├── anat
    │   │   │   ├── perf
    │   │   │   ├── dwi
    │   │   │   ├── func
    │   │   │   ├── beh
    │   │   │   ├── eeg
    │   │   │   ├── meg
    │   │   │   ├── ieeg
    │   │   │   └── pet
    │   │   └── ses-02
    │   └── sub-02
    └── derivatives
```

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- BIDS defines a file name nomenclature :

```
sub-01
└── ses-01
    ├── anat
    │   ├── sub-01_ses-01_acq-tse_T2w.nii
    │   └── sub-01_ses-01_T1w.nii.gz
    └── func
        ├── sub-01_ses-01_task-olfloc_run-01_bold.nii
        ├── sub-01_ses-01_task-olfloc_run-01_bold.json
        ├── sub-01_ses-01_task-olfloc_run-01_events.tsv
        └── sub-01_ses-01_task-olfloc_run-01_physio.tsv.gz
```

BIDS filenames:

- **suffix** preceded by an **underscore**
- **entity-label** pairs separated by **underscores**
- **Entities**, **labels**, **suffixes** can only contain letters and / or numbers.
- For a given **suffix**, some **entities** are required and some others are [optional].
- **Entity-label** pairs have a specific order in which they must appear in filename.

BIDS and metadata

```
sub-01
└── ses-01
    ├── anat
    │   ├── sub-01_ses-01_acq-tse_T2w.nii
    │   └── sub-01_ses-01_T1w.nii.gz
    └── func
        ├── sub-01_ses-01_task-olfloc_run-01_bold.nii
        ├── sub-01_ses-01_task-olfloc_run-01_bold.json
        ├── sub-01_ses-01_task-olfloc_run-01_events.tsv
        └── sub-01_ses-01_task-olfloc_run-01_physio.tsv.gz
```

- JSON files: JavaScript Object Notation
  - for attribute-values pairs
- TSV files : Tabulation Separated Values
  - for spreadsheet data

The BIDS ecosystem

BIDS is accompanied by a large ecosystem of tools and resources:

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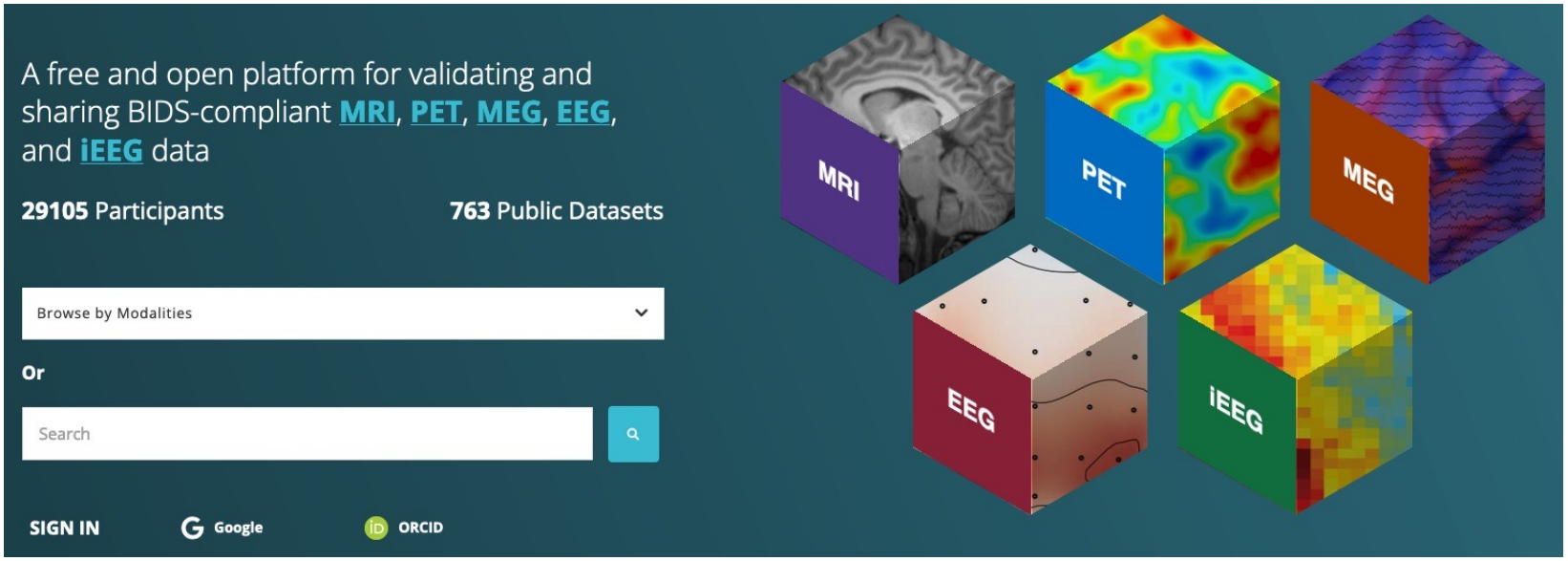
OpenNeuro: an international database that can host BIDS formatted datasets.



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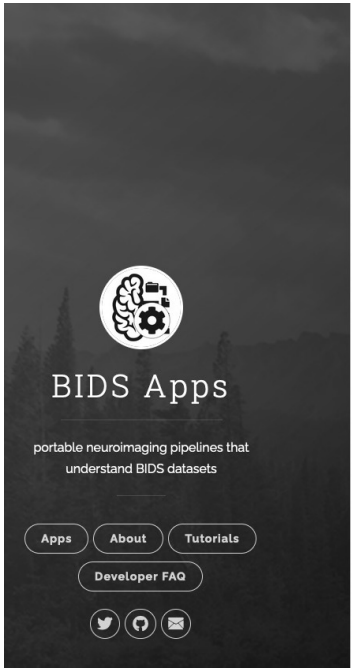
BIDS apps



Full BIDSification at INT

Some data types are easily transformed into BIDs and specifications have already been defined, for instance MRI, MEG, EEG, …

But: some data have no defined BIDS structure. We must define it ourselves

INT has started a project for handling all data in a BIDS format.

We started to define new BIDS format for :

- Animal electrophysiology: mono or multi-electrodes recordings in various experimental conditions and setups.
- Eye-tracking

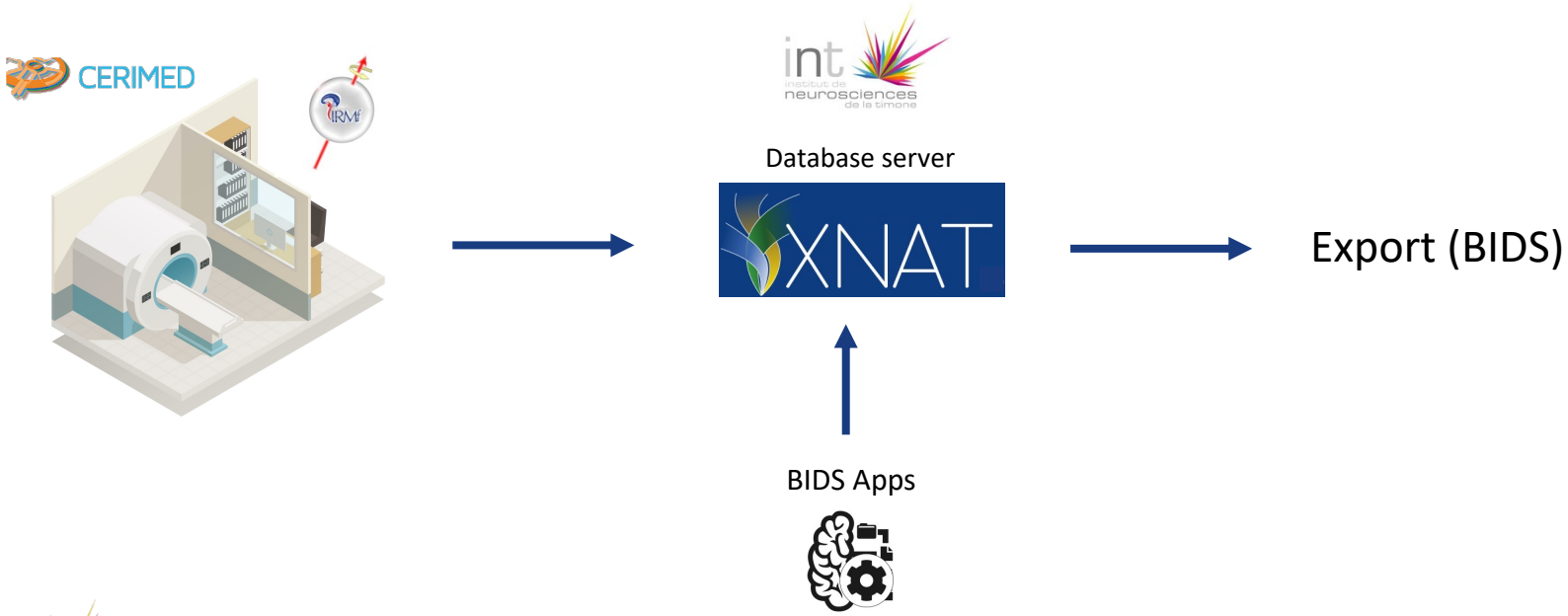
These two proposals have been accepted as official BIDS extension proposals (BEP020 and BEP032)

An easy case: Magnetic Resonance Imaging

The neuroimaging community was ahead in terms of open-science, reproducibility, and proper data management.

BIDS came from that community and MRI was the first data type to be handled.

Specific databasing tools are also available (Xnat)



Animal ePhys

2 challenges for animal electrophysiology:

- data structuration
- Metadata standardization

Specificities:

- A wide variety of experimental setups (hardware and experimental conditions), so we cannot stream directly from acquisition to storage.
- Metadata are not acquired automatically.
- Diversity of meta data: what metadata to track and how to standardize them into the BIDS structure ?

We developed

- A specific BIDS format (BIDS extension proposal 032)
- A stazndardized metadata collection process.

Animal ePhys – metadata collection

Requirements:

- User friendly interface
- Minimal overhead (resources, learning time)
- Usageof common terminologies
- Standardization across projects

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Use of existing resources at INT: REDCap Research Electronic Data Capture

- Browser-based tool for (meta)data capture via surveys
- Python API: PyCap (https://pycap.readthedocs.io)
- Registration / Export of collected data
- Text based (csv, json) representation of surveys and collected data

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Veuillez remplir le questionnaire ci-dessous.

Merci !

General

image

Ethical Protocol Identifier
* must provide value
APAFIS_13894_2018030217116218_v4

User
* must provide value

Session date
* must provide value
30-11-2022 Today D-M-Y

Experiment Name
* must provide value

Subject GUID
* must provide value

Incomplete session
yes
reset

Animal Behaviour
* must provide value
- Very motivated
- Working
- Thirsty
- Sleepy
- Unmotivated
- Agitated

Data recorded after last trial?
yes
reset

Fluid (reward)
in ml

Fluid (additional)
in ml

Other reward (additional)
- Fruit (fresh)
- Fruit (dry)
- Seeds
- Treats
- Insects

int Institut de neurosciences de la timone

Marseille université alement engagée

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Survey definition using DigLabTools
https://github.com/INT-NIT/DigLabTools

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Merci !

General

image

Ethical Protocol Identifier APAFIS_13894_2018030217116218_v4
* must provide value

User
* must provide value

Session date 30-11-2022 Today D-M-Y
* must provide value

Experiment Name
* must provide value

Subject GUID
* must provide value

Incomplete session yes reset

Animal Behaviour
* must provide value

- Very motivated
- Working
- Thirsty
- Sleepy
- Unmotivated
- Agitated

Data recorded after last trial? yes reset

Fluid (reward) in ml

Fluid (additional) in ml

Other reward (additional)

- Fruit (fresh)
- Fruit (dry)
- Seeds
- Treats
- Insects

int Institut de neurosciences de la timone

Marseille université alement engagée

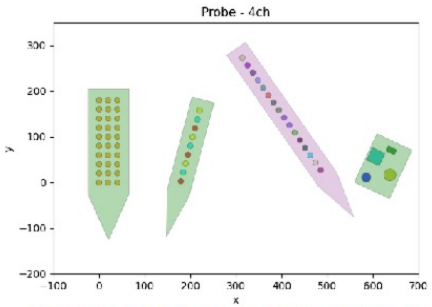
Animal ePhys – BIDS

BIDS Extension Proposal 032

http://bids.neuroimaging.io/bep032

Content:

- Open file format (nix/nwb)
- Probe and wiring description
- Metadata



https://probeinterface.readthedocs.io

an example...

```
my_dataset/
├── dataset_description.json
├── participants.json
├── participants.tsv
├── tasks.json
├── tasks.tsv
├── sub-i/
│   ├── sub-i_sessions.json
│   ├── sub-i_sessions.tsv
│   └── ses-140703/
│       └── ephys/
│           ├── sub-i_ses-140703_task-r2g_run-001_channels.tsv
│           ├── sub-i_ses-140703_task-r2g_run-001_contacts.tsv
│           ├── sub-i_ses-140703_task-r2g_run-001_ephys.json
│           ├── sub-i_ses-140703_task-r2g_run-001_ephys.nix
│           └── sub-i_ses-140703_task-r2g_run-001_probes.tsv
└── sub-l/
    ├── sub-l_sessions.json
    ├── sub-l_sessions.tsv
    └── ses-101210/
        └── ephys/
            ├── sub-l_ses-101210_task-r2g_run-001_channels.tsv
            ├── sub-l_ses-101210_task-r2g_run-001_contacts.tsv
            ├── sub-l_ses-101210_task-r2g_run-001_ephys.json
            ├── sub-l_ses-101210_task-r2g_run-001_ephys.nix
            └── sub-l_ses-101210_task-r2g_run-001_probes.tsv
```

Naming of files and directories :
- follows the generic rules of BIDS
- intuitive hierarchy (*project/animal/session/modality)*
- redundancy of information in file and directory names
- added specific infos for electrophysiology

Supported data file format (INCF standards) :
- NIX
- NWB

Supported metada file formats (as in generic BIDS) :
- tsv
- json

A larger picture

- MRI
- MEG/EEG
- Animal ePhy
- Microscopy
- Genetic data
- Behavioral data

A larger picture

BIDS

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A larger picture

2017: one of the first french labs to deliver full BIDS data

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Institut de neurosciences des systèmes

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ANR ShareElec
- BIDS extension
- Metadata standardization

REDCap

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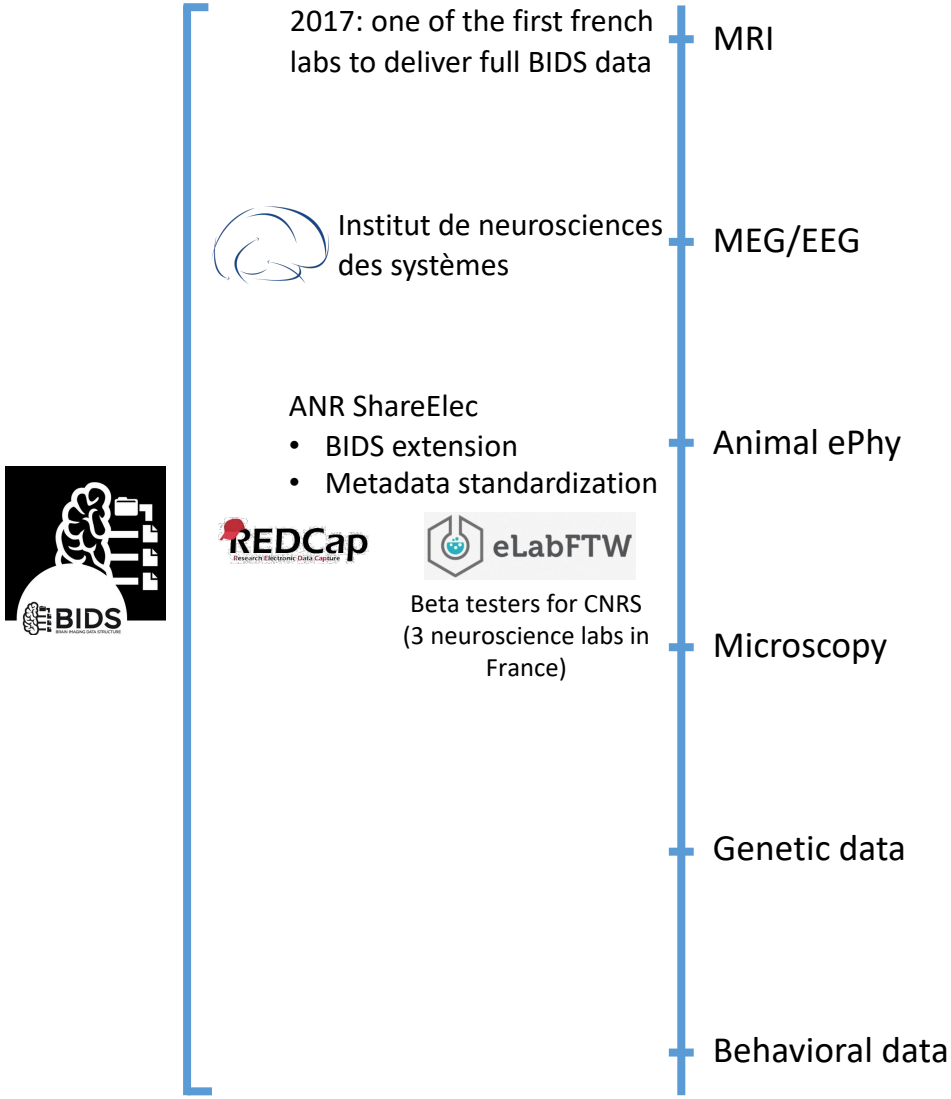

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eLabFTW

Beta testers for CNRS (3 neuroscience labs in France)

Genetic data

Behavioral data

BIDS extension for eye-tracking

A larger picture

IRM
Xnat +BIDS apps
automatic processing

MRI

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Institut de neurosciences des systèmes — MEG/EEG

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— Microscopy

OMERO @ datacenter

CEDRE INT/Inmed /IBDM

— Genetic data

BIDS extension for eye-tracking — Behavioral data

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2017: one of the first french labs to deliver full BIDS data

MRI

A unique Xnat server (INT/CRMBM) at datacenter ?

Institut de neurosciences des systèmes

MEG/EEG

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Microscopy

@ datacenter

CEDRE INT/Inmed /IBDM

Genetic data

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Behavioral data

Thank you !

INT

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ANR ShareElec