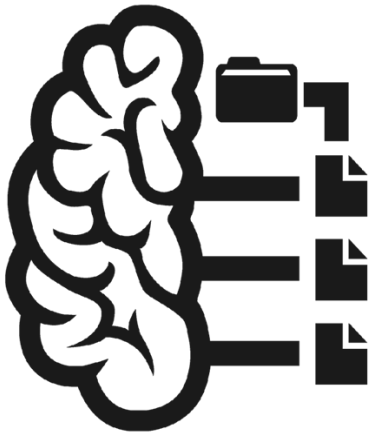


BIDS

BRAIN IMAGING DATA STRUCTURE

What is the Brain Imaging Data Structure and why you should know about this!

StepuP workshop - Zürich

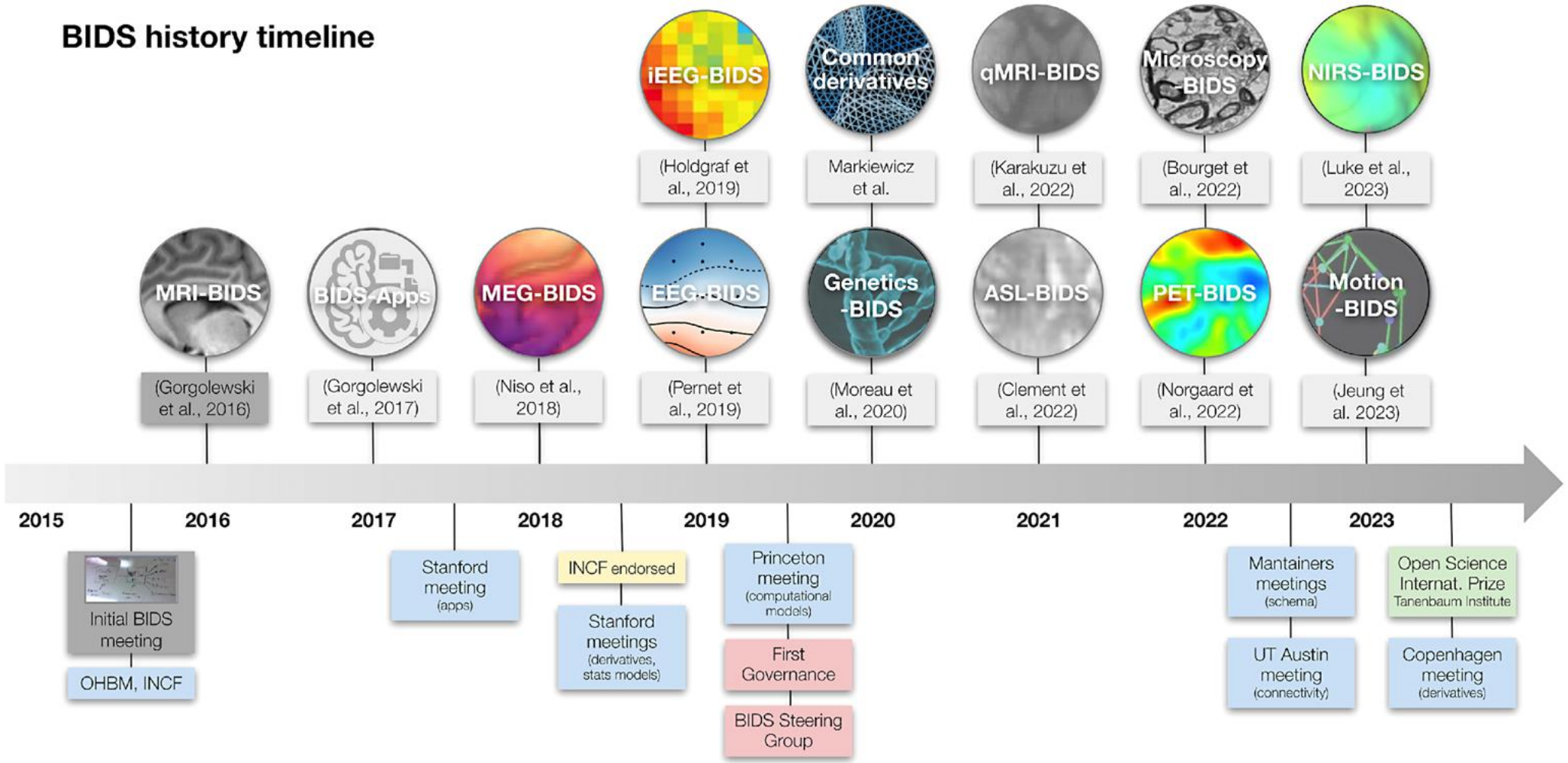
29/11/2024

Julius Welzel

```
├── README.md
├── dataset_description.json
├── participants.json
├── participants.tsv
└── sub-001
    ├── ses-01
    │   ├── eeg/
    │   └── motion/
    └── ses-02
└── sub-002
```

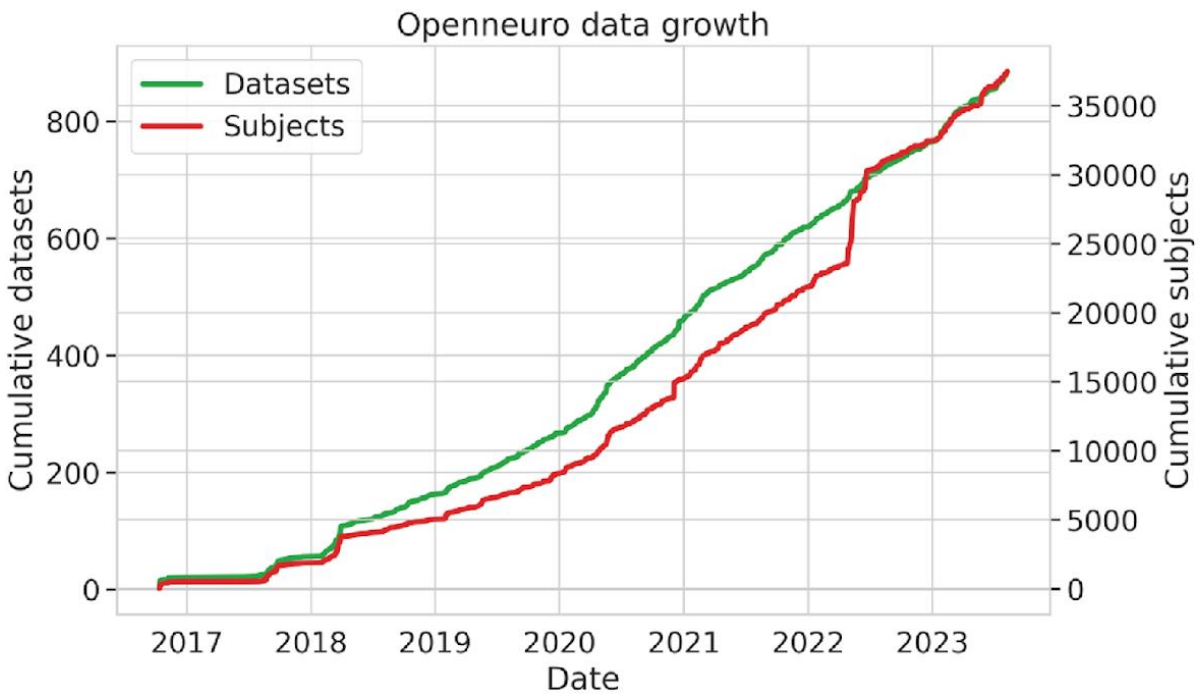
What is the Brain Imaging Data Structure and why you should know about this!

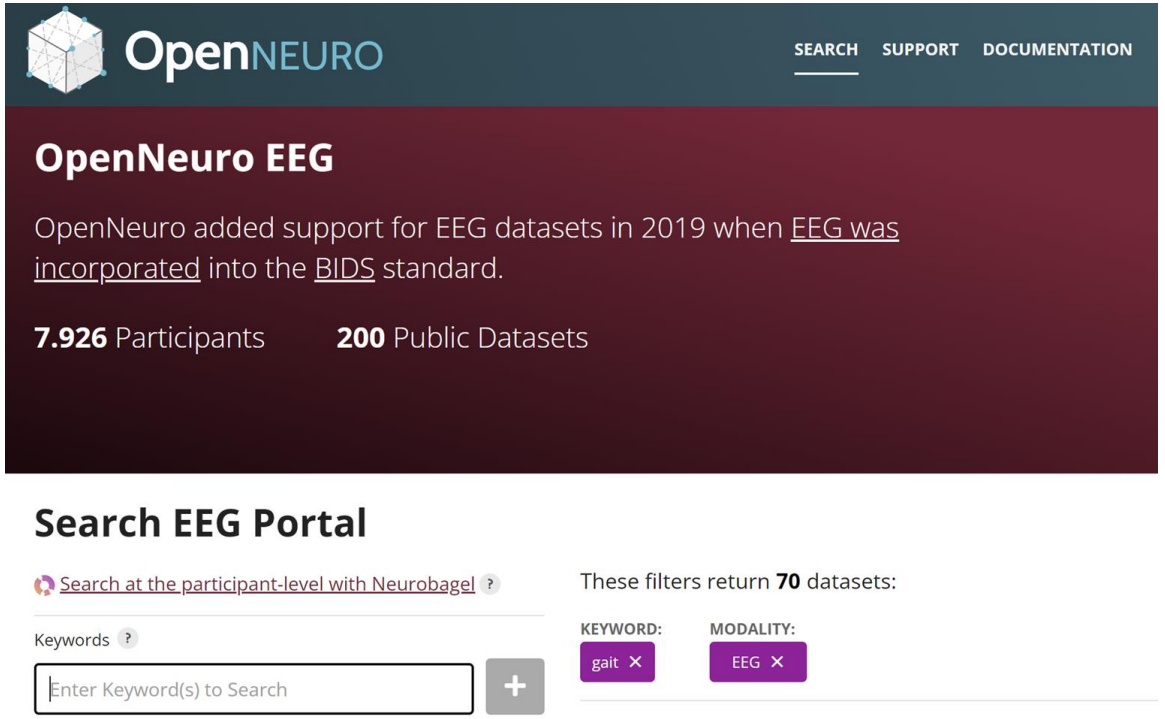
The Past, Present, and Future of BIDS



Poldrack ea., Imaging Neuroscience, 2024

The Past, Present, and Future of BIDS





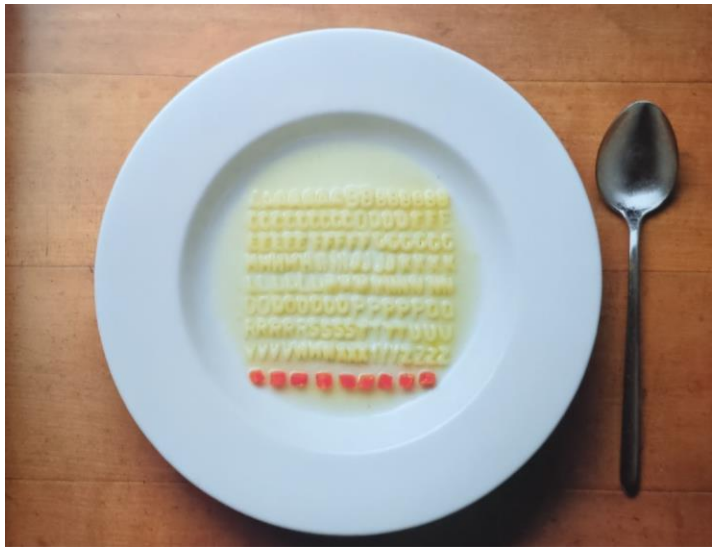
Poldrack ea., Imaging Neuroscience, 2024

What is BIDS?

About 20+ different EEG systems record in different file formats

Dataset info

Motion



Wascher ea., Human Factors, 2023

Aims of BIDS

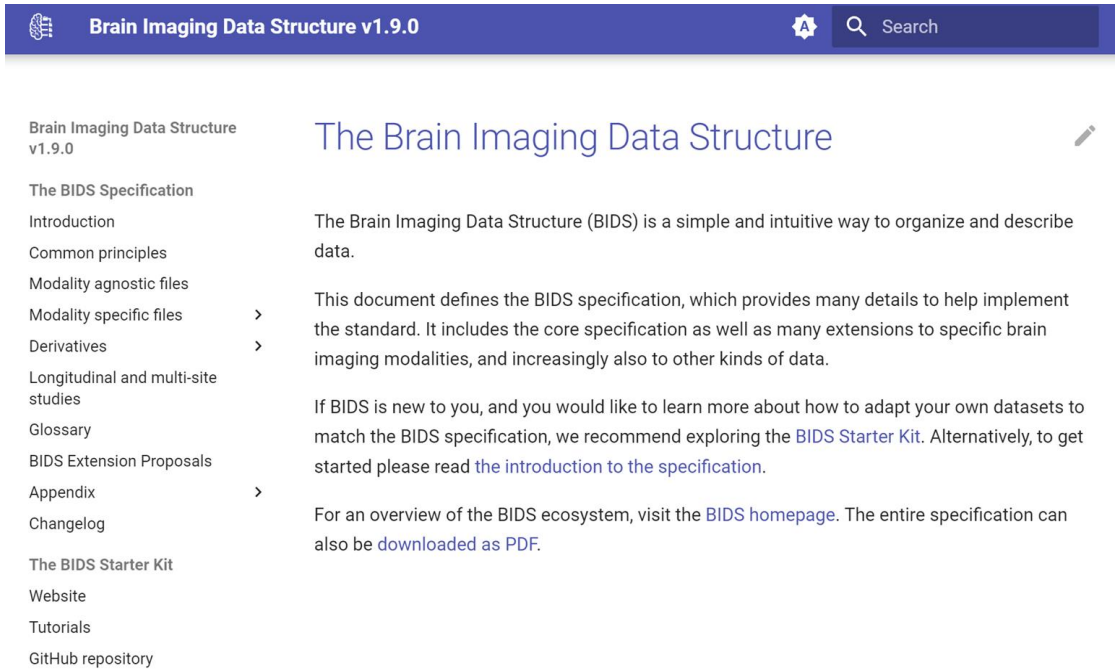
→ Makes (neuroimaging-)data FAIR

DATA STRUCTURE

- BIDS is based on simple file formats and folder structures
- Provides a “easy-to-understand” folder structure
- Provides a naming convention for files and directories
- Specifies file formats to use for modalities

METADATA

- Prevents metadata getting lost
- Some metadata is better than no metadata (80/20 rule)



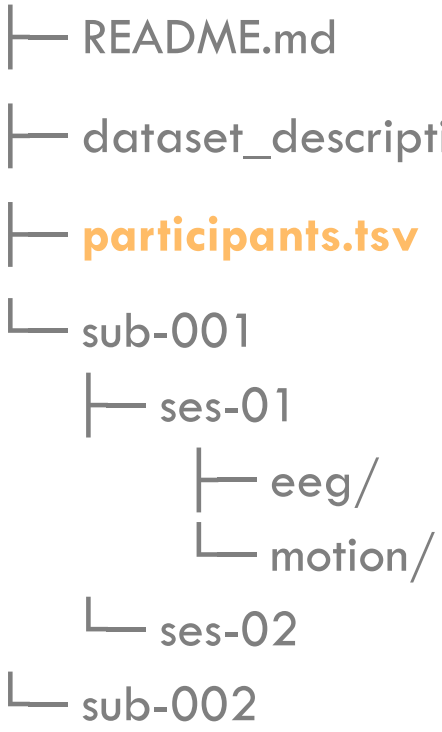
https://bids-specification.readthedocs.io/en/stable/

My favourite two BIDS principles

Requirement levels

Level of requirement **for** files and **within** files:

1. **REQUIRED**
2. **RECOMMENDED**
3. **OPTIONAL**



participant_id	age	group
sub-001	34	C
sub-002	12	P
sub-003	33	M

https://bids-specification.readthedocs.io/en/stable/03-modality-agnostic-files.html

BIDS definitions

Dataset - A set of neuroimaging and behavioral data acquired for a purpose of a particular study. A dataset consists of data acquired from one or more subjects, possibly from multiple sessions.

Subject - A person or animal participating in the study. Used interchangeably with term **Participant**.

Session - A logical grouping of neuroimaging and behavioral data consistent across subjects.

Task - A set of structured activities performed by the participant.

Overview files:

- participant.tsv
- scans.tsv
- …

Subject, session and task specific files

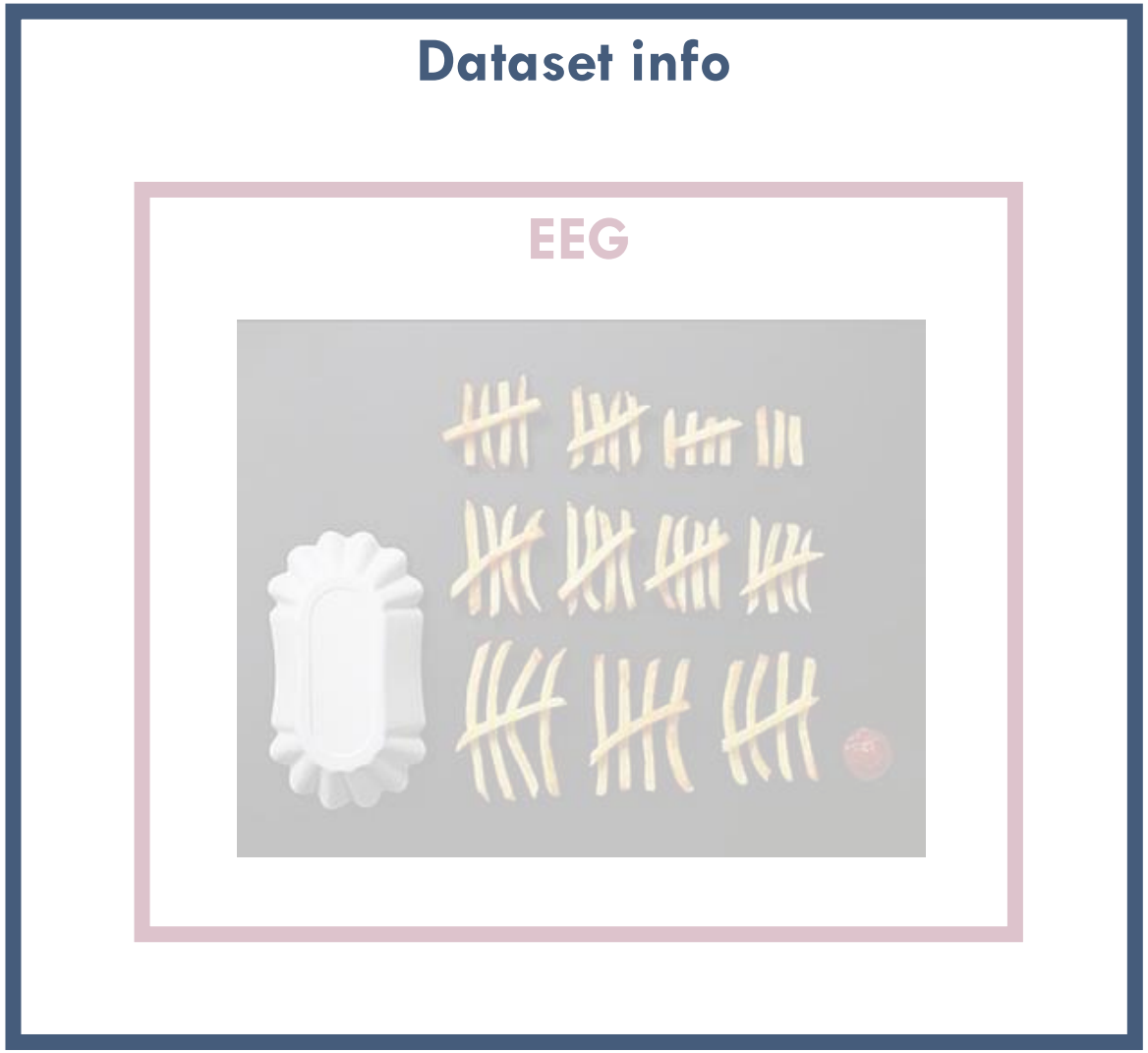
- sub-001_ses-01_task-GoNoGo.eeg
- sub-001_task-Oddball_channels.tsv

Directories and file naming structure

- Data for each subject are organized in subdirectories labeled **"sub-<label>"**, with "<label>" representing the unique identification label of each subject
- If subjects participated in multiple sessions, subdirectories labeled **"ses-<label>"** contain session-specific data within the subject directory
- Each session subdirectory (or the subject subdirectory if no session data exists) contains subdirectories for different data types, only defined if files are present for that type
- For a data file that was collected in a given **session** from a given **subject**, the file name **MUST** begin with the string sub-<label>[_ses-<label>]_task-<label>

```
├─ README.md
├─ dataset_description.json
├─ participants.json
├─ participants.tsv
└─ sub-001
   └─ ses-01
      └─ eeg/
         └─ sub-001_ses-01_task-GoNoGo.eeg
```

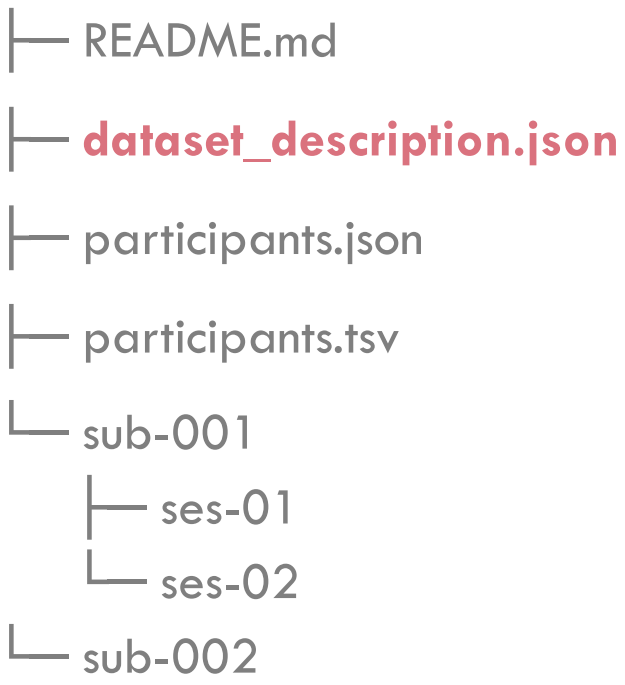
https://bids-specification.readthedocs.io/en/stable/common-principles.html#filesystem-structure-filenames-richness-versus-distinctness




```
├─ README.md
├─ dataset_description.json
├─ participants.json
├─ participants.tsv
└─ sub-001
   ├─ ses-01
   │  ├─ eeg/
   │  └─ motion/
   └─ ses-02
└─ sub-002
```

Modality agnostic data

dataset_description.json




```
{
"Name": "The mother of all experiments",
"BIDSVersion": "1.4.0",
"DatasetType": "raw",
"License": "CC0",
"Authors": [ "Paul Broca", "Carl Wernicke" ],
"Funding": [ „NIH F37823MFH1" ],
"EthicsApprovals": [„HRPO (Protocol  AR0928" ],
"DatasetDOI": "10.0.2.3/dfjj.10"
}
```

participants

```
├── README.md
├── dataset_description.json
├── participants.tsv
├── participants.json
└── sub-001
    ├── ses-01
    └── ses-02
└── sub-002
```

participants.tsv

participant_id	age	group
sub-001	34	C
sub-002	12	P
sub-003	33	M

participants.json

```
"age": {
    "Description": "age of the
    participant",  "Units": "years"
    },
„group": {
   "Description": „assigned group”,
   "Levels": {
      „C": „control",
      „M": „medication",
      „P": „placebo",
      }
```

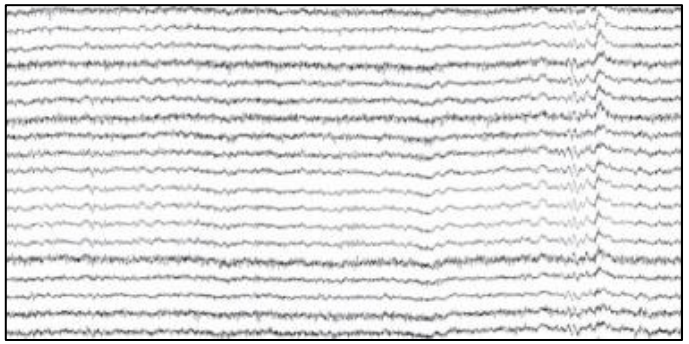
Dataset info

EEG

```
├── README.md
├── dataset_description.json
├── participants.json
├── participants.tsv
└── sub-001
    ├── ses-01
    │   ├── eeg/
    │   └── motion/
    └── ses-02
└── sub-002
```

Modality specific data

Files | eeg




```
{
    "TaskName": "TASKNAME",
    "SamplingFrequency": 1000,
    "SoftwareFilters": "n/a",
    "EEGChannelCount": 4,
    "EOGChannelCount": 1,
    "EEGReference": "placed on Cz",
    "PowerLineFrequency": 50
}
```


- sub-001
  - ses-01
    - eeg/
      - sub-001_ses-01_task-<label>_eeg.<extension>
      - sub-001_ses-01_task-<label>_eeg.json
      - sub-001_ses-01_task-<label>_channels.tsv
      - sub-001_ses-01_task-<label>_electrodes.tsv
      - sub-001_ses-01_task-<label>_electrodes.tsv

name	type	units	status	status_description
CP5	EEG	microV	good	n/a
FC5	EEG	microV	bad	high freq noise
FC1	EEG	microV	good	n/a
C3	EEG	microV	good	n/a
VEOG	EOG	microV	good	n/a

name	x	y	z	impedance
CP5	−0.77	−0.30	0.57	8
FC5	−0.77	0.30	0.57	12
FC1	−0.29	0.31	0.91	2
C3	−0.59	0.00	0.81	5
VEOG	n/a	n/a	n/a	n/a


```
{
    "EEGCoordinateSystem": "T1w",
    "EEGCoordinateUnits": "mm",
    "AnatomicalLandmarkCoordinates": {
        "LPA": [−0.067, 1.736e−09, −3.844e−09],
        "NAS": [−4.11e−09, 0.091, −4.541e−10],
        "RPA": [0.064, −6.435e−09, −4.566e−09]
    },
    "AnatomicalLandmarkCoordinateSystem": "T1w",
    "AnatomicalLandmarkCoordinateUnits": "mm",
    "IntendedFor": "sub−01_T1w.nii.gz"
}
```

Metadata | eeg.json

REQUIRED

TaskName, SamplingFrequency, PowerlineFrequency, EEGReference, SoftwareFilters

RECOMMENDED

TaskDescription, Manufacturer, EEGChannelCount, EOGChannelCount, …

OPTIONAL

-

```
{
  TaskName: Seeing stuff,
  SamplingFrequency: 2400,
  Manufacturer: Brain Products,
  ManufacturersModelName: BrainAmp DC,
  EEGChannelCount: 87,
  EOGChannelCount: 2,
  TriggerChannelCount: 1,
  PowerLineFrequency: 50,
  EEGPlacementScheme: 10 percent system,
  EEGReference: single electrode placed on FCz,
  SoftwareFilters: {
          Anti-aliasing filter: {
                  half-amplitude cutoff (Hz):
                  500,
                  Roll-off:  6dB/Octave
                  }
}
```

https://bids-specification.readthedocs.io/en/stable/04-modality-specific-files/03-electroencephalography.html#sidecar-json-_eegjson

Metadata | channels.tsv

REQUIRED

name, type, units

RECOMMENDED

-

OPTIONAL

description, sampling_frequency

name	type	units	description	reference	status	status_description
VEOG	VEOG	uV	left eye	VEOG-, VEOG+	good	n/a
FDI	EMG	uV	left first dorsal interosseous	FDI-, FDI+	good	n/a
Cz	EEG	uV	n/a	REF	bad	high frequency noise
UADC001	MISC	n/a	envelope of audio signal	n/a	good	n/a

https://bids-specification.readthedocs.io/en/stable/04-modality-specific-files/03-electroencephalography.html#channels-description-_channelstsv

Metadata | electrodes.tsv

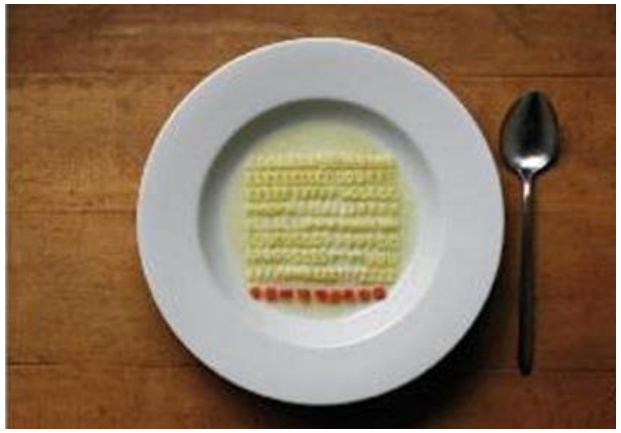
name	x	y	z	type	material	color
VEOG+	n/a	n/a	n/a	cup	Ag/AgCl	blue
VEOG-	n/a	n/a	n/a	cup	Ag/AgCl	white
FDI+	n/a	n/a	n/a	cup	Ag/AgCl	red
FDI-	n/a	n/a	n/a	cup	Ag/AgCl	red
GND	-0.07	0.00	-0.070	clip-on	Ag/AgCl	pink
Cz	0.00	0.07	0.06	cup	Ag/AgCl	yellow
REF	-0.07	-0.02	-0.01	cup	Ag/AgCl	grey

Column name	Requirement Level	Data type	Description
name	REQUIRED	string	Name of the electrode contact point. Values in `name` MUST be unique. This column must appear **first** in the file.
x	REQUIRED	number	Recorded position along the x-axis. This column must appear **second** in the file.
y	REQUIRED	number	Recorded position along the y-axis. This column must appear **third** in the file.
z	REQUIRED	number or `"n/a"`	Recorded position along the z-axis. This column must appear **fourth** in the file.
type	RECOMMENDED	string	Type of the electrode (for example, cup, ring, clip-on, wire, needle). This column may appear anywhere in the file.
material	RECOMMENDED	string	Material of the electrode (for example, `Tin`, `Ag/AgCl`, `Gold`). This column may appear anywhere in the file.
impedance	RECOMMENDED	number	Impedance of the electrode, units MUST be in `kOhm`. This column may appear anywhere in the file.
Additional Columns	OPTIONAL	`n/a`	Additional columns are allowed if they are defined in the associated metadata file.

https://bids-specification.readthedocs.io/en/stable/04-modality-specific-files/03-electroencephalography.html#electrodes-description-_electrodestsv

Dataset info

Motion



```
├── README.md
├── dataset_description.json
├── participants.json
├── participants.tsv
└── sub-001
    ├── ses-01
    │   ├── eeg/
    │   └── motion/
    └── ses-02
└── sub-002
```

Modality specific data

Files | motion

```
└─ sub-001/
   └─ ses-01/
      ├─ eeg/
      ...
      └─ motion/
         ├─ sub-001_ses-01_task-<label>_tracksys-<label>_motion.tsv
         ├─ sub-001_ses-01_task-<label>_tracksys-<label>_motion.json
         └─ sub-001_ses-01_task-<label>_channels.tsv
```

0,2634511	0,092295	0,0086682	0,9305117	0,690106	0,8098815
0,694520	0,1918243	0,8437273	0,3975710	0,885496	0,8952724
0,0766395	0,2587211	0,5434792	0,2822837	0,2789791	0,2326254
0,5779993	0,0456141	0,0490745	0,9408899	0,1533421	0,6683652
0,054556	0,7915927	0,5871733	0,4669577	0,9754468	0,0480541
0,966024	0,1962834	0,7114406	0,3389448	0,7194495	0,4384892
0,984172	0,5079461	0,1180168	0,7966978	0,1753768	0,4886533
0,9883907	0,1557346	0,8002013	0,6334882	0,7526906	0,8529441
…	…	…	…	…	…


```
{
"SamplingFrequency": 60,
"SamplingFrequencyEffective": 60.19,
"TaskName": "BIDS Motion fictive example",
"TrackingSystemName": "imu1",
"TaskDescription": "walking and talking",
"MotionChannelCount": 6,
„SubjectArtefactDescription": "n/a",
"TrackedPointsCount" : 2,
"ACCELChannelCount": 3,
„GYROChannelCount": 3,
"Manufacturer": "BWSensing",
"ManufacturersModelName": "BW-imu600",
}
```


name	component	type	tracked_point	units	placement
imu1_rf_acc_x	x	ACCEL	rf	m/s^2	right_foot
imu1_rf_acc_y	y	ACCEL	rf	m/s^2	right _foot
imu1_rf_acc_z	z	ACCEL	rf	m/ s^2	right _foot
imu1_rf_gyro_x	x	GYRO	rf	rad/s	right _foot
imu1_rf_gyro_y	y	GYRO	rf	rad/s	right _foot
imu1_rf_gyro_z	z	GYRO	rf	rad/s	right _foot

https://bids-specification.readthedocs.io/en/stable/modality-specific-files/motion.html

Metadata | motion.json

REQUIRED

TaskName, SamplingFrequency

RECOMMENDED

TaskDescription, RecordingDuration, MotionChannelCount, <type>ChannelCount, SoftwareFilters, …

OPTIONAL

Manufacuturer, RecordingSoftware, …


```
{
 "SamplingFrequency": 60,
 "TaskName": "BIDS Motion fictive example",
 "TrackingSystemName": "IMU Right Hand",
 "TaskDescription": "walking and talking",
 "InstitutionAddress": "Fictive address",
 "InstitutionName": "Fictive Institution",
 "MotionChannelCount": 18,
 "RecordingDuration": 4667.641106,
 "SubjectArtefactDescription": "n/a",
 "TrackedPointsCount" : 2,
 "ACCELChannelCount": 6,
 "GYROChannelCount": 6,
 "MAGNChannelCount": 6,
 "Manufacturer": "BWSensing",
 "ManufacturersModelName": "BW-IMU600",
}
```


https://bids-specification.readthedocs.io/en/stable/modality-specific-files/motion.html#sidecar-json-_motionjson

Metadata | channels.tsv

REQUIRED

name, component, type, tracked_point, units

RECOMMENDED

placement, reference_frame

OPTIONAL

status, status_description, sampling_frequency

Restricted keyword list for channel type

Restricted keyword list for column `type` in alphabetic order. Note that upper-case is REQUIRED:

Keyword	Description
ACCEL	Accelerometer channel, one channel for each spatial axis. Column component for the axis MUST be added to the `*_channels.tsv` file (x, y, or z).
ANGACCEL	Angular acceleration channel, one channel for each spatial axis. Column component for the axis MUST be added to the `*_channels.tsv` file (x, y, or z).
GYRO	Gyrometer channel, one channel for each spatial axis. Column component for the axis MUST be added to the `*_channels.tsv` file (x, y, or z).
JNTANG	Joint angle channel between two fixed axis belonging to two bodyparts. Angle SHOULD be defined between proximal and distal bodypart in deg.

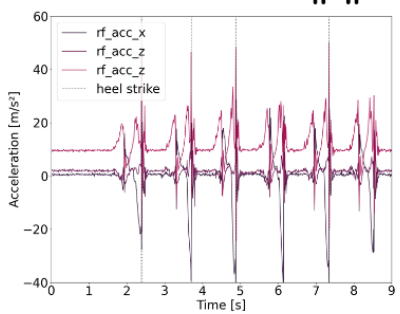
name	component	type	tracked_point	units	reference_frame
t1_acc_x	x	ACCEL	LeftFoot	m/s^2	global
t1_acc_y	y	ACCEL	LeftFoot	m/s^2	global
t1_acc_z	z	ACCEL	LeftFoot	m/s^2	global
t1_gyro_x	x	GYRO	LeftFoot	rad/s	global
t1_gyro_y	y	GYRO	LeftFoot	rad/s	global
t1_gyro_z	z	GYRO	LeftFoot	rad/s	global

…

https://bids-specification.readthedocs.io/en/stable/04-modality-specific-files/03-electroencephalography.html#channels-description-_channelstsv

Overview | motion

0,26345511	0,092292015	0,008668652	0,930514317	0,690193606	0,809881135
0,694520294	0,191824943	0,843726573	0,397571025	0,88542996	0,895276224
0,076633595	0,258720111	0,547534792	0,282283781	0,27890791	0,232620594
0,577995093	0,045616941	0,04903375	0,940889749	0,153318421	0,668360752
0,054555716	0,791513927	0,587116733	0,466957774	0,975446368	0,048053341
0,966026984	0,196283834	0,711044406	0,338944328	0,719445195	0,438488392
0,98417512	0,507944361	0,1180168	0,796692478	0,175376468	0,488659533
0,98839607	0,155737146	0,800206213	0,633481382	0,752698206	0,852943441
...	...	...	...	...	...



- README
- dataset_description.json
- participants.tsv
- participants.json
- sub-001
  - motion
    - sub-001[_ses-01]_task-<label>_tracksys-<label>_motion.tsv
    - sub-001[_ses-01]_task-<label>_tracksys-<label>_motion.json
    - sub-001[_ses-01]_task-<label>_tracksys-<label>_events.tsv
    - sub-001[_ses-01]_task-<label>_tracksys-<label>_events.json
    - sub-001[_ses-01]_task-<label>_tracksys-<label>_channels.tsv
- sub-002
  - motion
    - sub-002[_ses-01]_task-<label>_tracksys-<label>_motion.tsv
    - ...


```
{
   "SamplingFrequency": 60,
   "SamplingFrequencyEffective": 60.19,
   "TaskName": "BIDS Motion fictive example",
   "TrackingSystemName": "imu1",
   "TaskDescription": "walking and talking",
   "MotionChannelCount": 6,
   "RecordingDuration": 10.05,
   "SubjectArtefactDescription": "n/a",
   "TrackedPointsCount" : 2,
   "ACCELChannelCount": 3,
   „GYROChannelCount": 3,
   "Manufacturer": "BWSensing",
   "ManufacturersModelName": "BW-imu600",
}
```


onset	duration	trial_type
2.45	0.1	heel_strike
3.81	0.1	heel_strike
4.95	0.1	heel_strike
6.11	0.1	heel_strike
7.24	0.1	heel_strike

name	type	units	srate	tracked_point	component	placement
imu1_rf_acc_x	ACCEL	m/s^2	222	rf	x	right_foot
imu1_rf_acc_y	ACCEL	m/s^2	222	rf	y	right _foot
imu1_rf_acc_z	ACCEL	m/s^2	222	rf	z	right _foot
imu1_rf_gyro_x	GYRO	rad/s	222	rf	x	right _foot
imu1_rf_gyro_y	GYRO	rad/s	222	rf	y	right _foot
imu1_rf_gyro_z	GYRO	rad/s	222	rf	z	right _foot

Jeung ea., Scientific Data, 2024

Dataset info

Events

```
├─ README.md
├─ dataset_description.json
├─ participants.json
├─ participants.tsv
└─ sub-001
   ├─ ses-01
   │  ├─ eeg/
   │  └─ motion/
   └─ ses-02
└─ sub-002
```

Synchronize modalities

scans.tsv

sub-<label>/

[ses-<label>/]

sub-<label>[_ses-<label>]_scans.tsv

Column name	Requirement Level	Data type	Description
filename	REQUIRED	string	Relative paths to files. There MUST be exactly one row for each file. Values in `filename` MUST be unique. This column must appear **first** in the file.
acq_time	OPTIONAL	string	Acquisition time refers to when the first data point in each run was acquired. Furthermore, if this header is provided, the acquisition times of all files from the same recording MUST be identical. Datetime format and their anonymization are described in Units. This column may appear anywhere in the file.
Additional Columns	OPTIONAL	`n/a`	Additional columns are allowed.

filename	acq_time
eeg/sub-control01_task-nback.eeg	1877-06-15T13:45:30
eeg/sub-control01_task-walking.eeg	1877-06-15T13:55:33
motion/sub-control01_task-walking.tsv	1877-06-15T13:56:27

*nback.eeg

*walking.eeg

*walking.tsv

What is the Brain Imaging Data Structure and **why you should know about this!**

For research

- Validation and optimizing pipelines

Article | Open access | Published: 09 February 2023

EEG is better left alone

Arnaud Delorme

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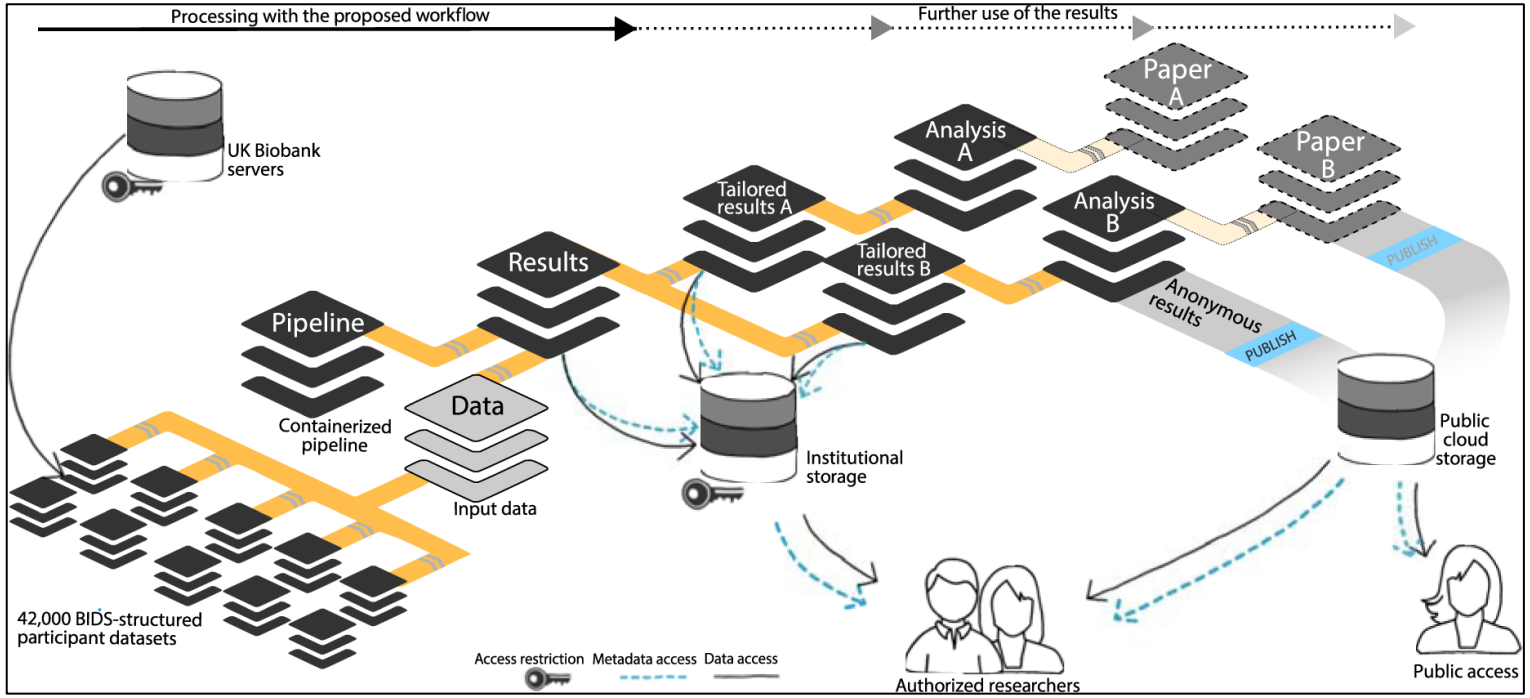
Preprocessing Choices for P3 Analyses with Mobile EEG:A Systematic Literature Review and Interactive Exploration

Nadine S. J. Jacobsen, Daniel Kristanto, Suong Welp, Yusuf Cosku Inceler, Stefan Debener

doi: https://doi.org/10.1101/2024.04.30.591874

- Building a sustainable research environment

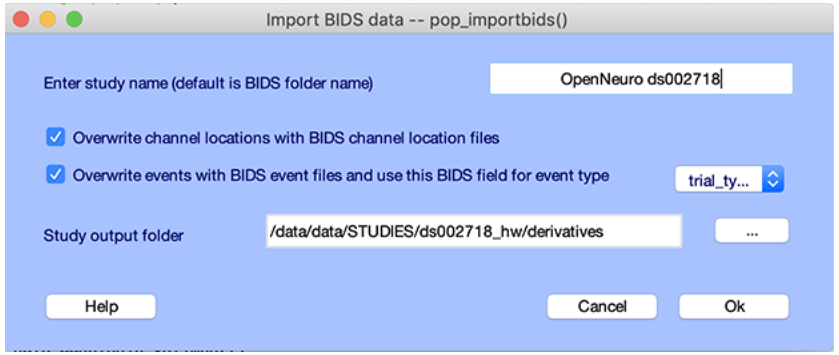


Delorme, Scientific Reports, 2023; Jacobsen ea., bioRxiv, 2024; Wagner ea., Scientific Data, 2022

For you

Load public data from the BIDS format

- EEGLab, FieldTrip and MNE provide importers



Converting your data to BIDS

- Reuse data from your Lab and others
- Foster collaborations

```
sub = {'01', '02', '03', '04', '05', '06', '07', '08', '09', '10'};

% for subject 3 the age is unknown, for subject 2 the sex is not specified
age = [11  96  nan 77  82  87  18 40  26  80];
sex = {'f' [] 'f' 'f' 'f' 'm' 'm' 'm' 'm' 'm'};

for subindx=1:numel(sub)

  cfg = [];
  cfg.datatype  = 'eeg';

  % Load your data
  cfg.dataset   =  sub{subindx} + '.edf';

  % specify the output directory
  cfg.bidsroot  = 'bids';

  cfg.sub       = sub{subindx};

  % specify the information for the participants.tsv file
  % this is optional, you can also pass other pieces of info
  cfg.participants.age = age(subindx);
  cfg.participants.sex = sex{subindx};


  % provide the mnemonic and long description of the task
  cfg.TaskName        = 'changedetection';
  cfg.TaskDescription = 'Subjects were responding as fast as possible upon a
                         change in a visually presented stimulus.';

  % these are EEG specific
  cfg.eeg.PowerLineFrequency = 50;   % since recorded in the EU
  cfg.eeg.EEGReference       = 'M1'; % left mastoid

  data2bids(cfg);

end
```

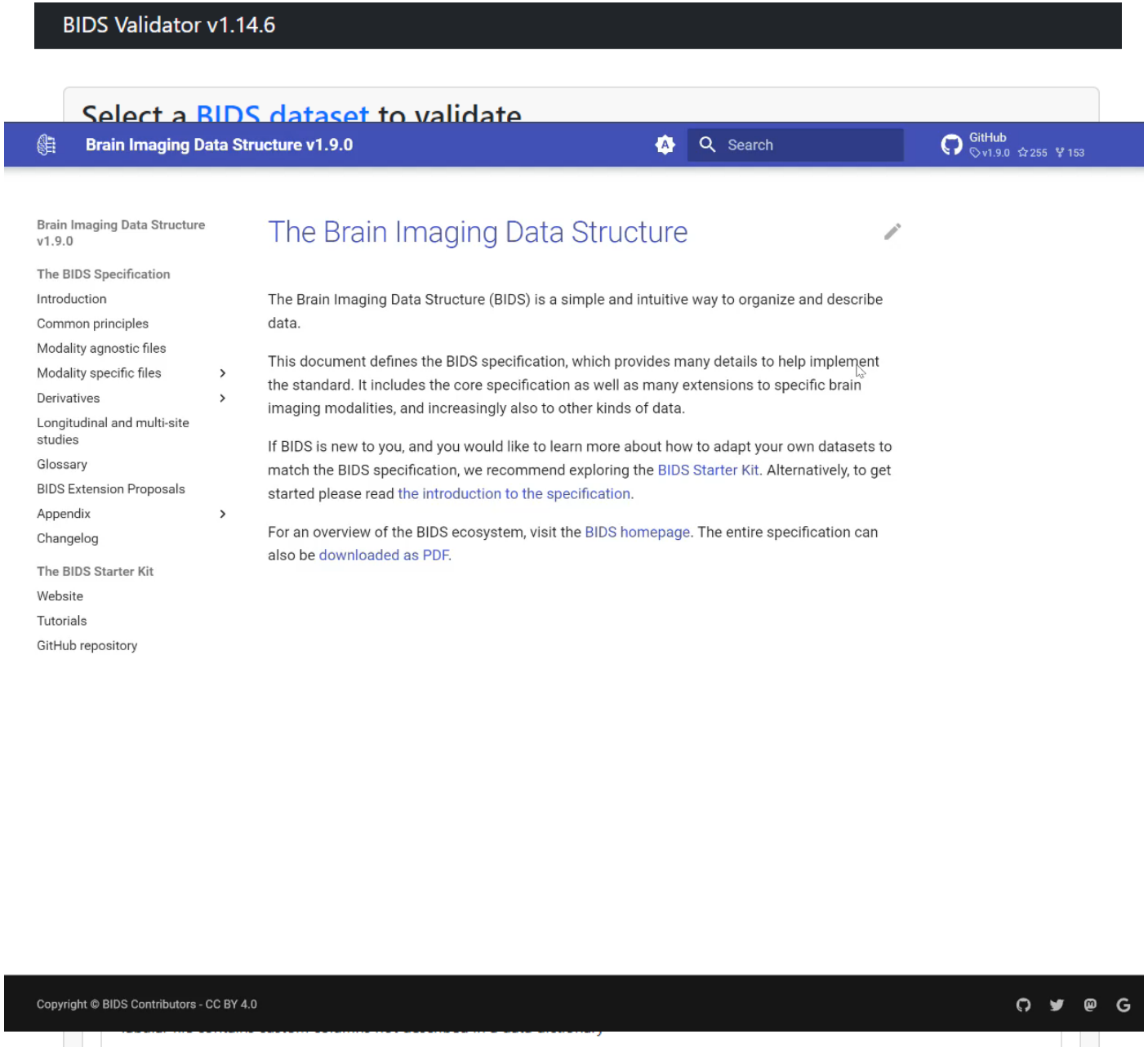
BIDS Starterpack

Website

[https://bids-specification.readthedocs.io/en/stable/]

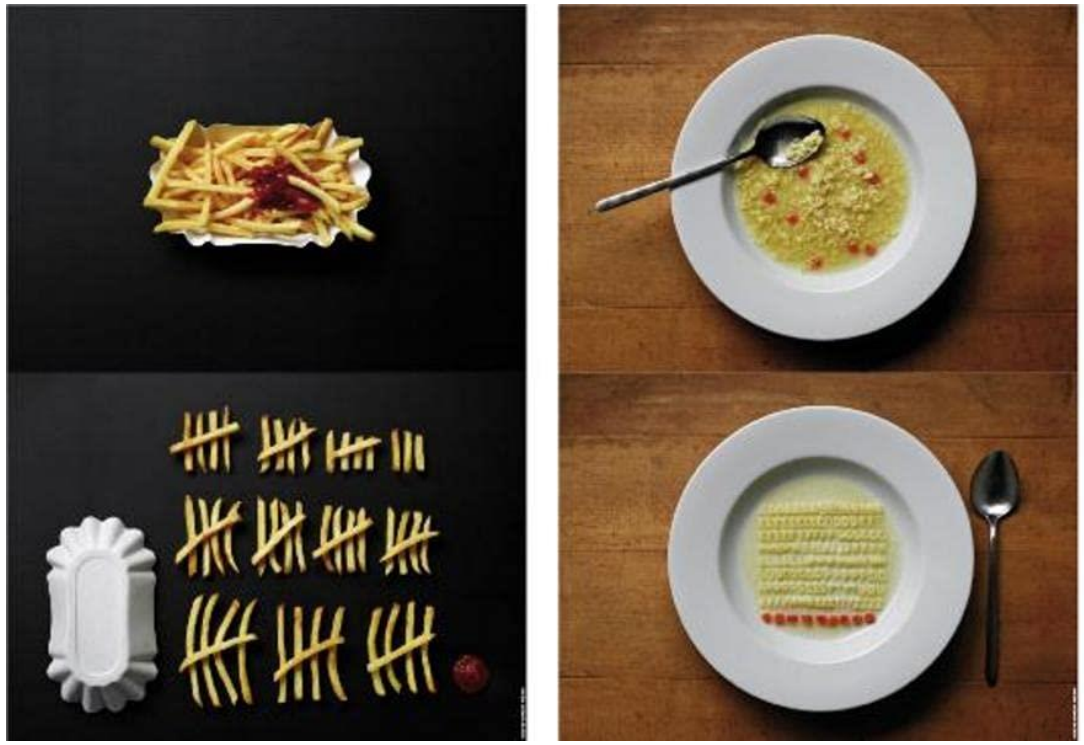
Validator

[https://bids-standard.github.io/bids-validator/]

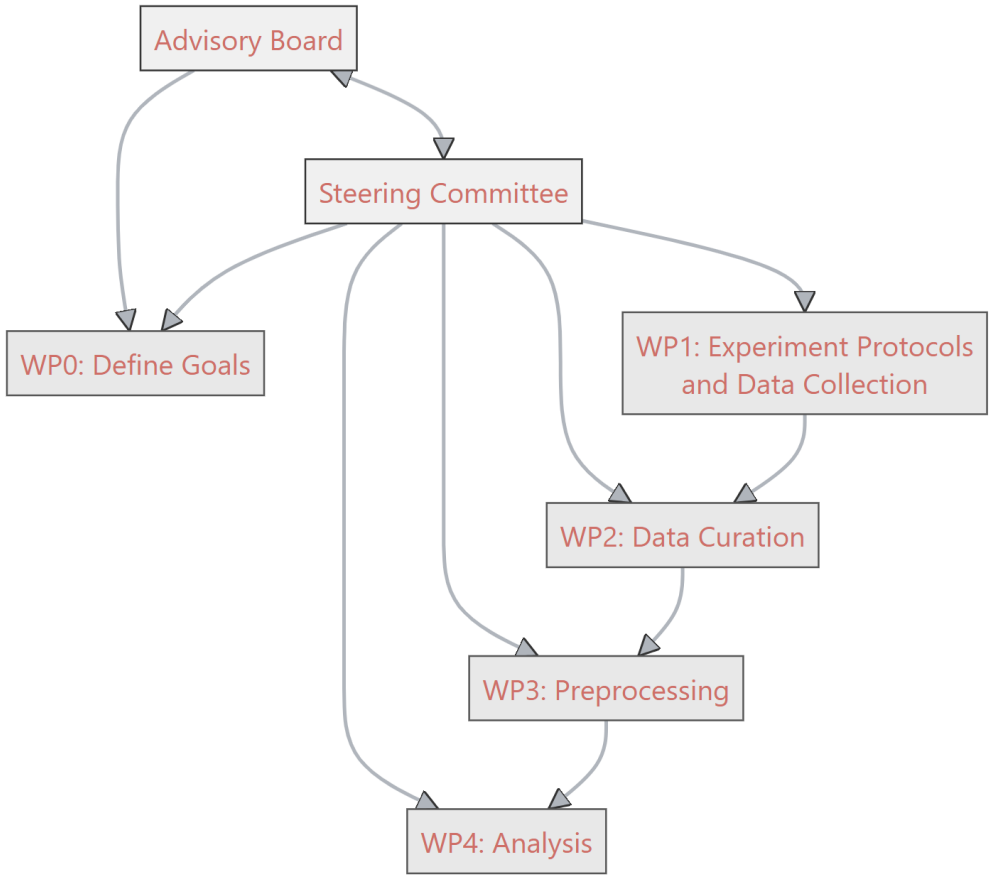


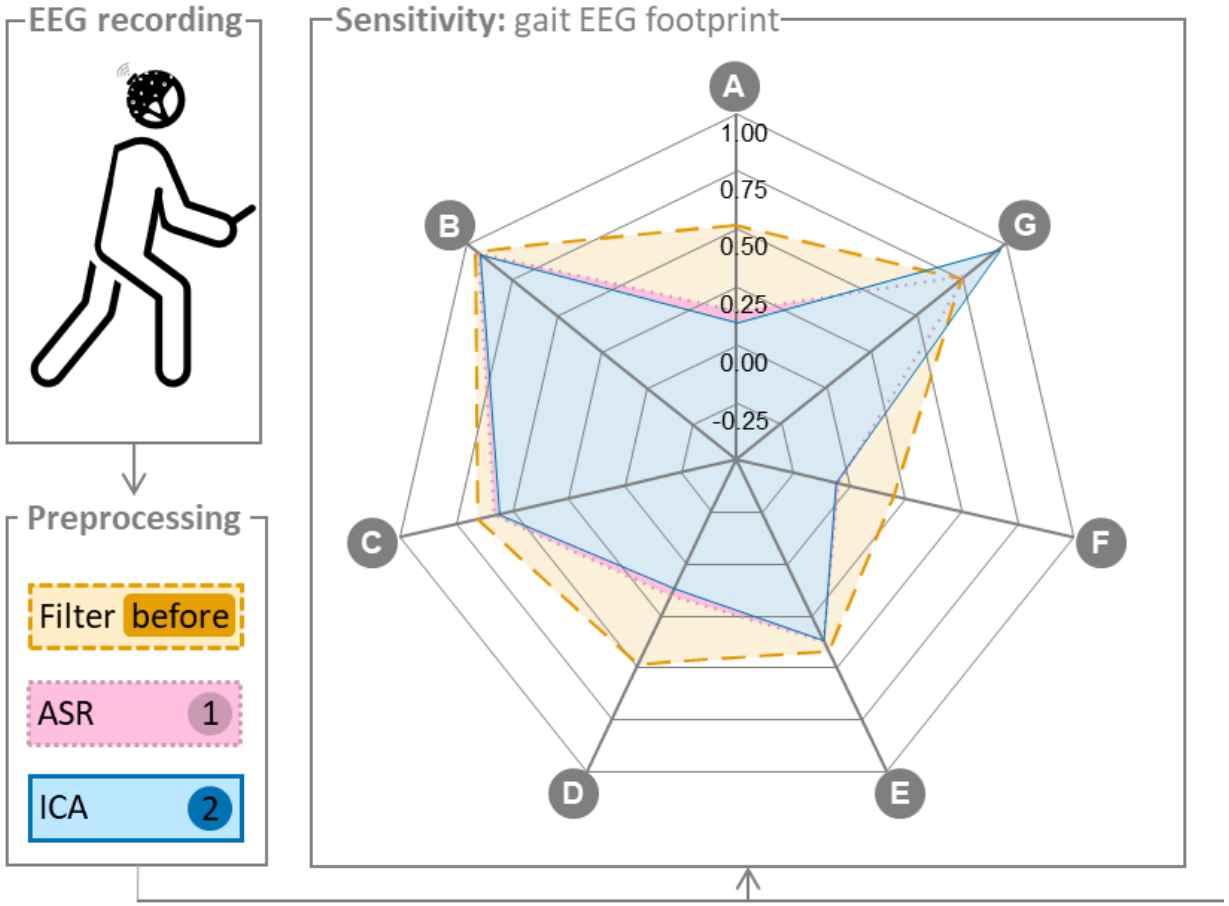
Conclusions

BIDS
BRAIN IMAGING DATA STRUCTURE



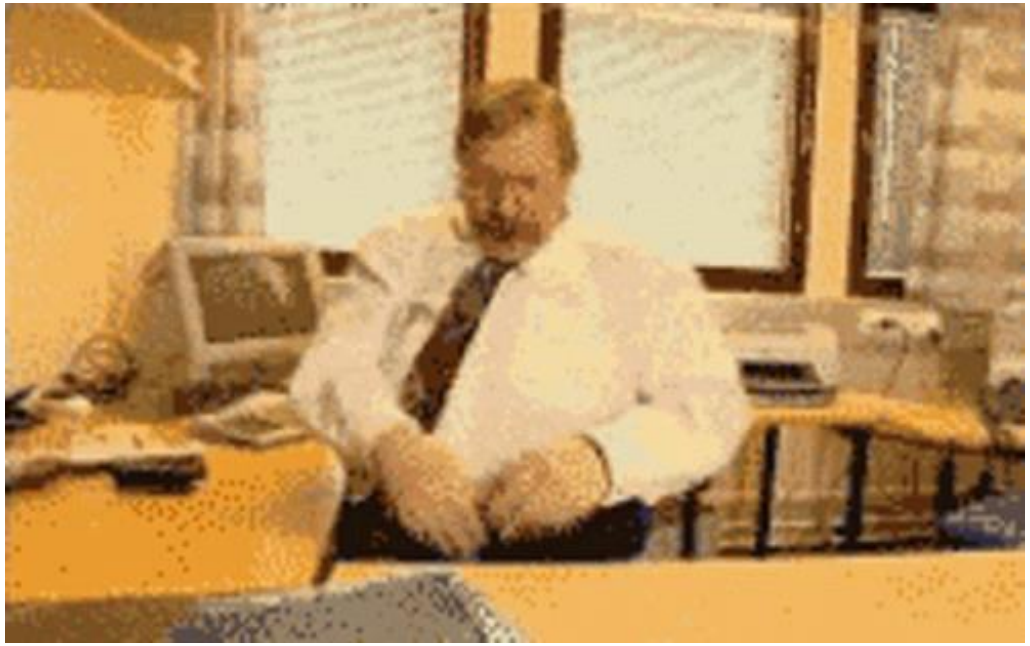
Outlook: EEGManySteps





https://juliuswelzel.github.io/eegmanysteps/; Jacobsen ea., European Journal of Neuroscience, 2020

Thank you for listening carefully



Thanks to **Sein Jeung** for pushing this to completion over the past three years
Thanks to all of the **BIDS Maintainers and Devs** who help to implement this
Thanks to my **working group,** who have given me the freedom to work in this
Thanks to all **participants** who ever provided data which is now in BIDS