



How to organise (motion) data

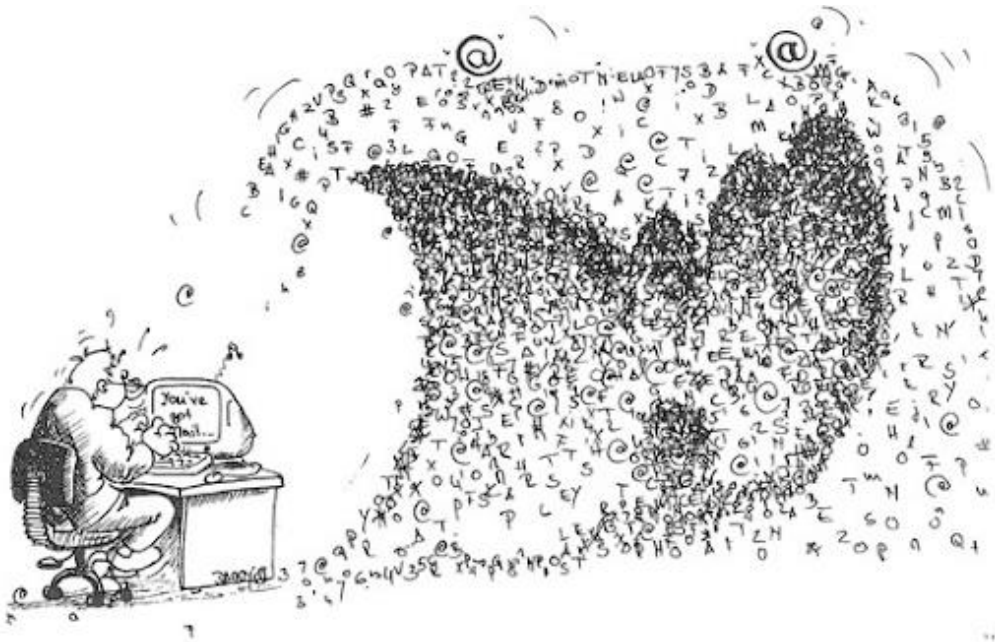
12.10.2021 – AG-Meeting





WHAT

Motivation



- Tens of thousands subjects are scanned for research purposes each year
- Lack of consensus leads to misunderstanding and time wasted on **rearranging data** or **rewriting scripts** that expect particular file formats and **organization**

What is BIDS?

BIDS is based on **simple file** formats and folder structures

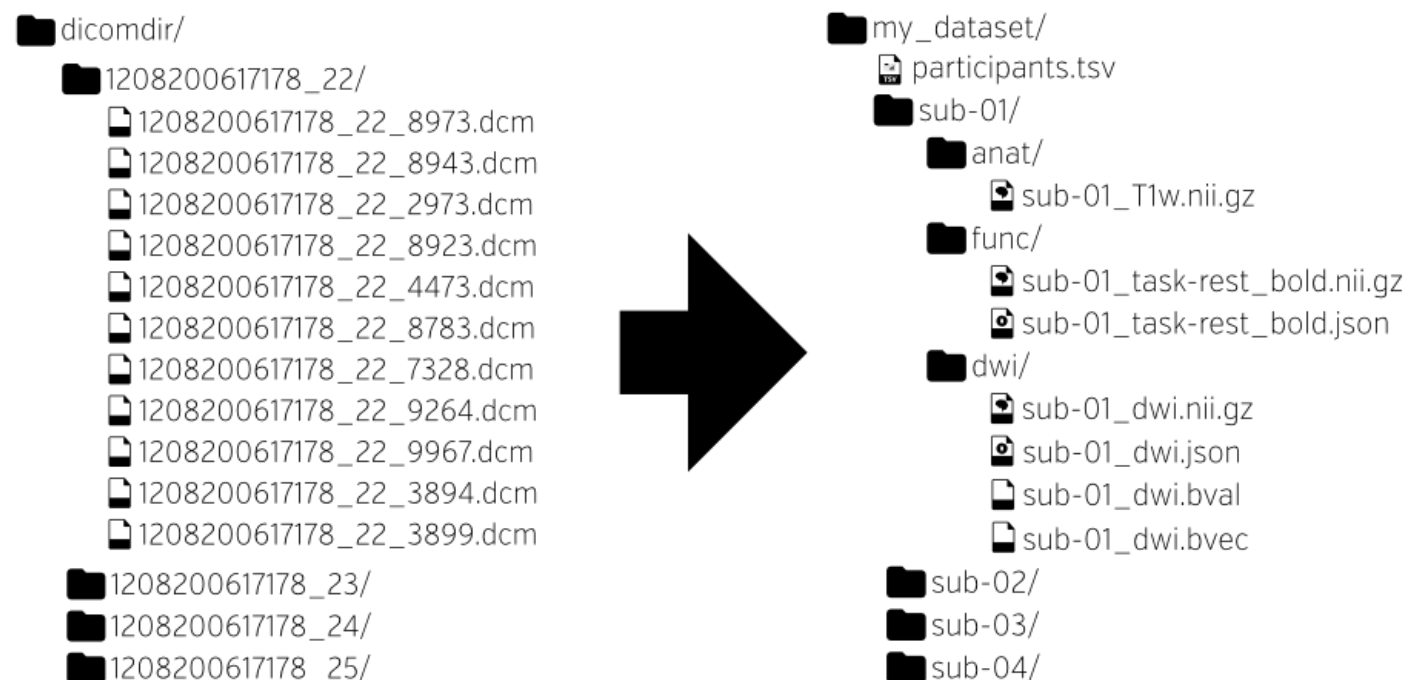
DATA STRUCTURE

- File formats to use (e.g. `nifti`, `json`, `tsv`) → [BIDS is NOT a file format]
- Naming convention for files and directories

METADATA

- Prevents metadata getting lost while doing your research
- Stored in `json` files, readable by both humans and machines
- Some metadata is better than no metadata

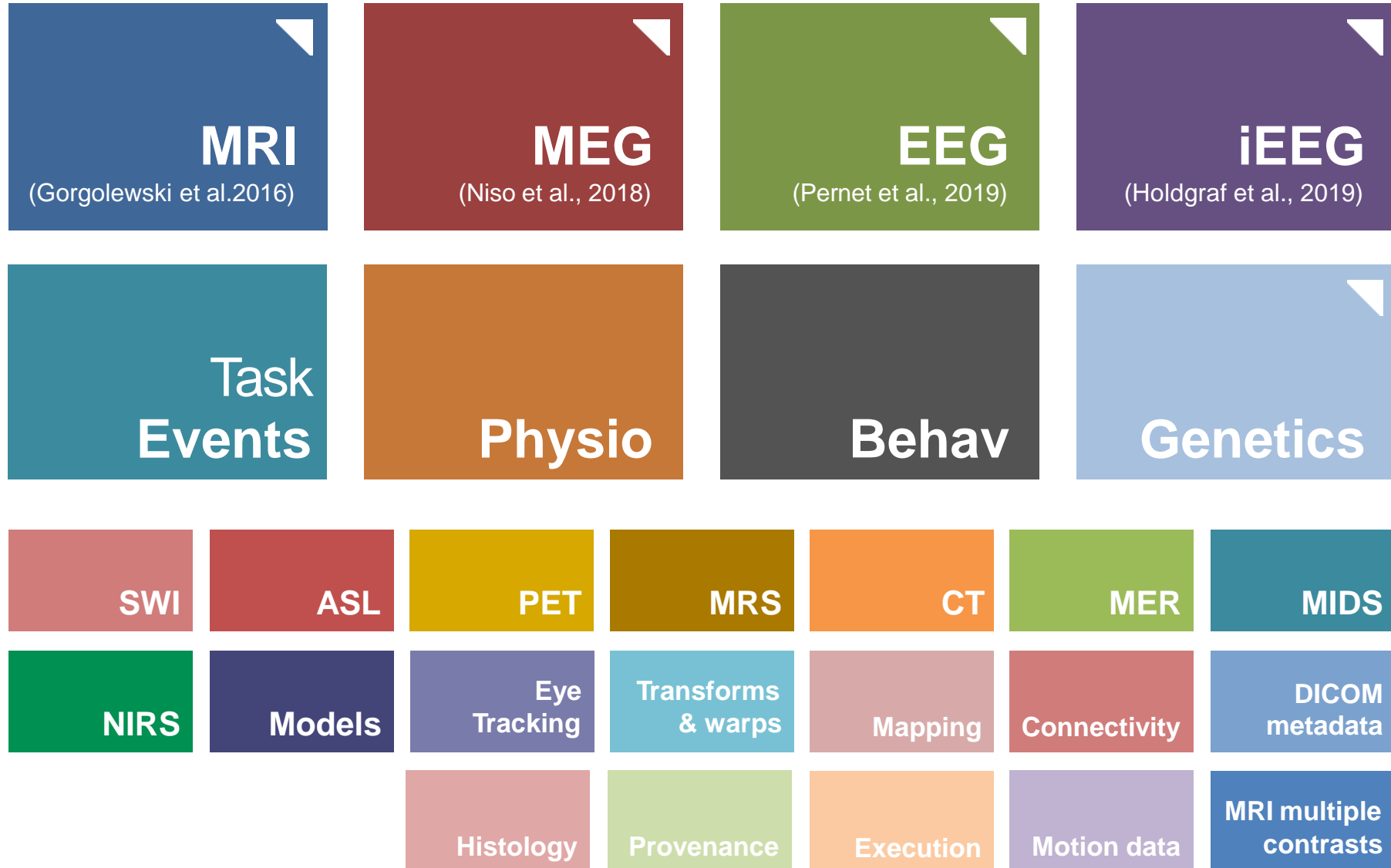
History

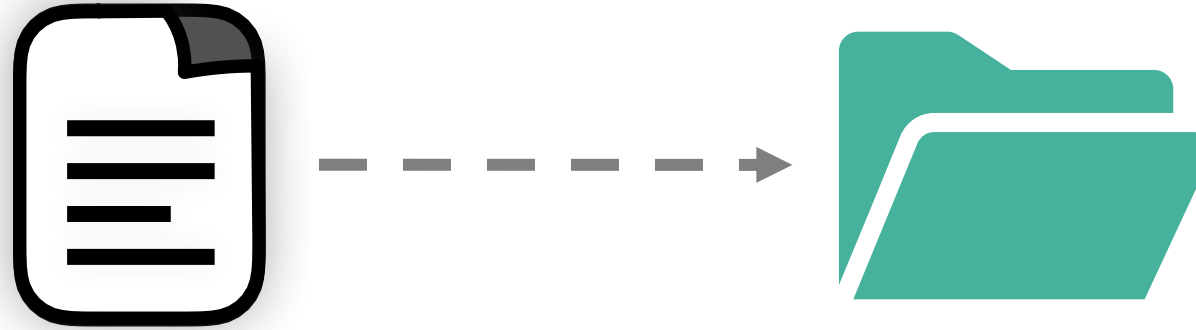


Adoption of a common standards to describe data and its organization **on disk:**

1. Data remain accessible and usable by different researchers over time
2. Errors attributed to the misunderstanding of the meaning of a given datum
3. Standardized usage of data analysis software

BIDS universe





BIDS Specification

<https://bids-specification.readthedocs.io>

Example1/

Where do we want to go?

```
| - README.tsv
| - dataset_description.json
| - participants.json
| - participants.tsv
└ - sub-001
    | - ses-01
    |     | - eeg/
    |     | - motion/
    |         | - sub-01_ses-01_task-BalanceTandemStand_tracksys-IMU1_motion.tsv
    |         | - sub-01_ses-01_task-BalanceTandemStand_motion.json
    |         | - sub-01_ses-01_task-BalanceTandemStand_channels.tsv
    | - ses-02
    └ - sub-001_scans.tsv
| - sub-002
└ - sub-003
```

Definitions

- **Dataset** - A dataset consists of data acquired from one or more subjects, possibly from multiple sessions.
- **Subject**
- **Session** - a logical grouping of neuroimaging and behavioral data consistent across subjects. Session can (but doesn't have to) be synonymous to a visit in a longitudinal study.
- **Task** - a set of structured activities performed by the participant. Tasks are usually accompanied by stimuli and responses, and can greatly vary in complexity.
- **Event** - something that happens or may be perceived by a test subject as happening at a particular instant during the recording. Events are most commonly associated with on- or offset of stimulus presentations, or with the distinct marker of on- or offset of a subject's response or motor action.
- **Data type** - a functional group of different types of data. BIDS defines eight data types: func (task based and resting state functional MRI), dwi, anat (structural imaging such as T1, T2 and so on), meg (magnetoencephalography), eeg (electroencephalography), ieeg (intracranial electroencephalography), beh (behavioral), *motion (time series of object positions, orientations, or their time derivatives)*.
- [...]

Common principles

Level of requirement:

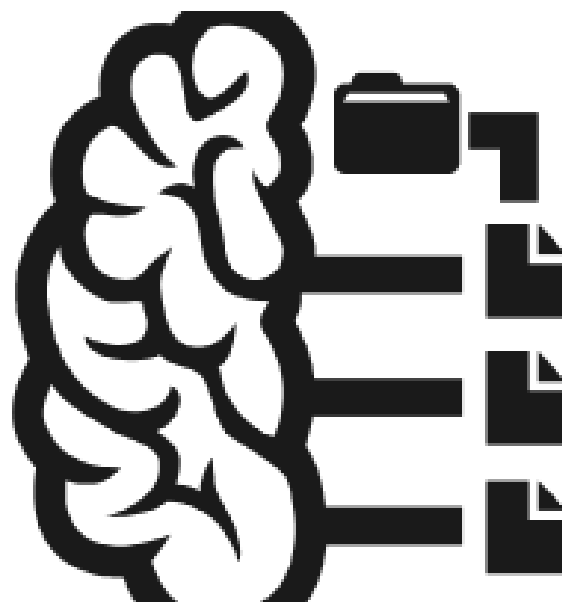
1. **MUST**
2. **RECOMMENDED**
3. **OPTIONAL**

Inheritance principle

- Any metadata file (such as .json or .tsv) may be defined at any directory level, but no more than one applicable file may be defined at a given level

Example1/

```
|— README.tsv
|— dataset_description.json
|— participants.json
|— participants.tsv
|— task-BalanceTandemStand.json
└— sub-001
    |— ses-01
        |— eeg/
        |— motion/
    └— ses-02
|— sub-002
└— sub-003
```



Modality agnostic data

BIDS schema: example

Example1/

```
└─ README.tsv
└─ dataset_description.json
└─ participants.json
└─ participants.tsv
├─ sub-001
│   ├── ses-01
│   ├── ses-02
│   └─ sub-001_scans.tsv
└─ sub-002
└─ sub-003
```

dataset_description.json

```
{
  "Name": "The mother of all
  experiments", "BIDSVersion":
  "1.4.0",
  "DatasetType":
  "raw", "License":
  "CC0",
  "Authors": [ "Paul Broca", "Carl Wernicke" ],
  "Acknowledgements": "Special thanks to KB for help in
  formatting this dataset in BIDS",
  "HowToAcknowledge": "Please cite this paper:
  https://www.ncbi.nlm.nih.gov/pubmed/0928",
  "Funding": [ "National Institute of Neuroscience Grant
  F37823MFH1" ], "EthicsApprovals": [ "Human Research
  Protections Office (Protocol AR0928" ],
  "ReferencesAndLinks": [
  "https://www.ncbi.nlm.nih.gov/pubmed/ 0928", "Alzheimer et
  al (2015). Nature, 21. doi.org/0928" ], "DatasetDOI":
  "10.0.2.3/dfjj.10"
}
```

BIDS schema: example

Example1/

```
└─ README.tsv
└─ dataset_description.json
└─ participants.json
└─ participants.tsv
├─ sub-001
│   ├── ses-01
│   ├── ses-02
│   └─ sub-001_scans.tsv
└─ sub-002
└─ sub-003
```

participants.json

```
"age": {
  "Description": "age of
the participant",
  "Units": "years" },
"sex": {
  "Description": "sex as
reported by the participant",
  "Levels": {
    "M": "male",
    "F": "female" }
```

participants.tsv

participant_id	age	sex
sub-001	34	M
sub-002	12	F
sub-003	33	F

BIDS schema: example

Example1/

```
|— README.tsv
|— dataset_description.json
|— participants.json
|— participants.tsv
└— sub-001
    |— ses-01
    |— ses-02
    └— sub-001_scans.tsv
|— sub-002
└— sub-003
```

sub-001_scans.tsv

filename	acq_time
ses-01/sub001-ses-01_task-TuG.csv	2019-06-15T13:45:30
ses-01/sub001-ses-01_task-DualTask.csv	2019-06-15T13:52:42
ses-02/sub001-ses-01_task-TuG.csv	2020-03-22T14:11:12



Motion specific data

Metadata | modality specific - motion

Example1/

└─ sub-001/ses-01/

└─ eeg/

...

└─ motion/

sub-001_ses-01_task-<label>[_tracksys-<label>]_motion.tsv

sub-001_ses-01_task-<label>_motion.json

sub-001_ses-01_task-<label>_channels.tsv

sub-001_ses-01_task-<label>_coordsystem.json

sub-001_ses-01_task-<label>_events.tsv

sub-001_ses-01_task-<label>_events.json

Metadata | motion.json

MUST

TaskName, MotionTrackedPoints,
StartTime, TrackingSystem,
SamplingFrequency

RECOMMENDED

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

OPTIONAL

Manufacturer, RecordingSoftware,
...

```
{  
  TaskName: BIDS Motion fictive example,  
  TaskDescription: Running around,  
  StartTime: 2019-06-15T13:45:30 ,  
  RecordingDuration: 4667.641106,  
  TrackingSystemCount : 1,  
  MotionTrackedPoints : 1,  
  MotionChannelCount: 6,  
  TrackingSystems:{  
    IMU1 : {  
      Manufacturer: HasoMed,  
      TrackedPointsCount: 1,  
      SamplingFrequency: 120,  
      SoftwareFilters:n/a,  
      ACCChannelCount: 3,  
      GYROChannelCount: 3,  
    }  
  }  
}
```

Metadata | channels.tsv

name	type	units	srate	
IMU1_lf_acc_x	ACC	m/s^2	222	
IMU1_lf_acc_y	ACC	m/s^2	222	lf
IMU1_lf_acc_z	ACC	m/s^2	222	lf
IMU1_lf_gyro_x	GYRO	rad/s	222	lf
IMU1_lf_gyro_y	GYRO	rad/s	222	lf
IMU1_lf_gyro_z	GYRO	rad/s	222	lf

MUST tracked_point, tracking_system, type, units

TOWARDS A UNIFIED PLACEMENT SYSTEM FOR MOTION CAPTURE USING INERTIAL MEASUREMENT UNITS

A PREPRINT

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system

1

Metadata | motion.tsv

- Headers correspond to `channels.tsv <name>`
- Raw values from recording

IMU1_lf_acc_x	IMU1_lf_acc_y	IMU1_lf_acc_z	IMU1_lf_gyro_x	IMU1_lf_gyro_y	IMU1_lf_gyro_z
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
0,557959342	0,095962723	0,802817734	0,749838438	0,847351997	0,2385044
0,199349532	0,183812353	0,657496925	0,891828079	0,363756585	0,059946057
0,96627098	0,727173308	0,520638452	0,759135101	0,351863205	0,813096032
...

Metadata | modality specific - motion

Example1/

└─ sub-001/ses-01/

└─ eeg/

...

└─ motion/

sub-001_ses-01_task-<label>[_tracksys-<label>]_motion.tsv

sub-001_ses-01_task-<label>_motion.json

sub-001_ses-01_task-<label>_channels.tsv

sub-001_ses-01_task-<label>_coordsystem.json

sub-001_ses-01_task-<label>_events.tsv

sub-001_ses-01_task-<label>_events.json

IMU1_lf_acc_x	IMU1_lf_acc_y	IMU1_lf_acc_z	IMU1_lf_gyro_x	IMU1_lf_gyro_y	IMU1_lf_gyro_z
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
0,557959342	0,095962723	0,802817734	0,749838438	0,847351997	0,2385044
0,199349532	0,183812353	0,657496925	0,891828079	0,363756585	0,059946057
0,96627098	0,727173308	0,520638452	0,759135101	0,351863205	0,813096032
...

```
{
  "TaskName": "BIDS Motion fictive example",
  "TaskDescription": „Running around",
  „StartTime": „ 2019-06-15T13:45:30 ",
  "RecordingDuration": 4667.641106,
  "TrackingSystemCount" : 1,
  "MotionTrackedPoints" : 1,
  "MotionChannelCount": 6,
  "TrackingSystems":{

    "IMU1": {
      "Manufacturer":
        "BWSensing",
      "TrackedPointsCount": 1,
      "SamplingFrequency": 120,
      "SoftwareFilters": "n/a",
      "ACCChannelCount": 3,
      "GYROChannelCount": 3,
    }
  }
}
```

name	type	units	srate	tracked_point	component	placement	tracking_system
IMU1_lf_acc_x	ACC	m/s^2	222	lf	x	left_foot	IMU1
IMU1_lf_acc_y	ACC	m/s^2	222	lf	y	left_foot	IMU1
IMU1_lf_acc_z	ACC	m/s^2	222	lf	z	left_foot	IMU1
IMU1_lf_gyro_x	GYRO	rad/s	222	lf	x	left_foot	IMU1
IMU1_lf_gyro_y	GYRO	rad/s	222	lf	y	left_foot	IMU1
IMU1_lf_gyro_z	GYRO	rad/s	222	lf	z	left_foot	IMU1

Conclusions



Conclusions

Example1/

```
| - README.tsv
| - dataset_description.json
| - participants.json
| - participants.tsv
└ - sub-COKI10001
    | - ses-T1
    |   └ - motion/
    |     | - sub-01_ses-01_task-BalanceTandemStand_tracksys-HasoMedImu_motion.tsv
    |     | - sub-01_ses-01_task-BalanceSideBySide_tracksys-HasoMedImu_motion.tsv
    |     | - sub-01_ses-01_motion.json
    |     └ - sub-01_ses-01_channels.tsv
    | - ses-T2
    └ - sub-COKI10001_scans.tsv
| - sub-COKI10002
└ - sub-COKI10003
```





Thank you for listening carefully 😊

Thanks to Clint, Elke, Robbin
Special thanks to Sein Jeung (Berlin)

File naming structure

- A file name consists of a chain of *entities*, or key-value pairs, a *suffix* and an *extension*. Two prominent examples of entities are **subject** and **session**.
- 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>*

e.g. ComOn :

-> *sub-COKI10152_ses-T1_task-BalanceTandemStand.csv*