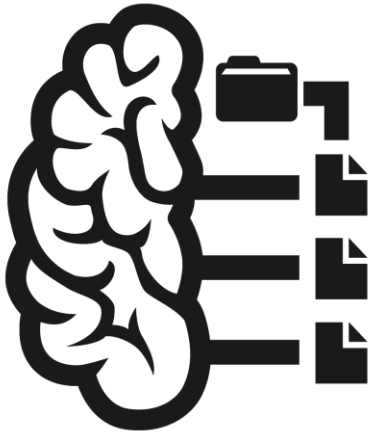


BIDS

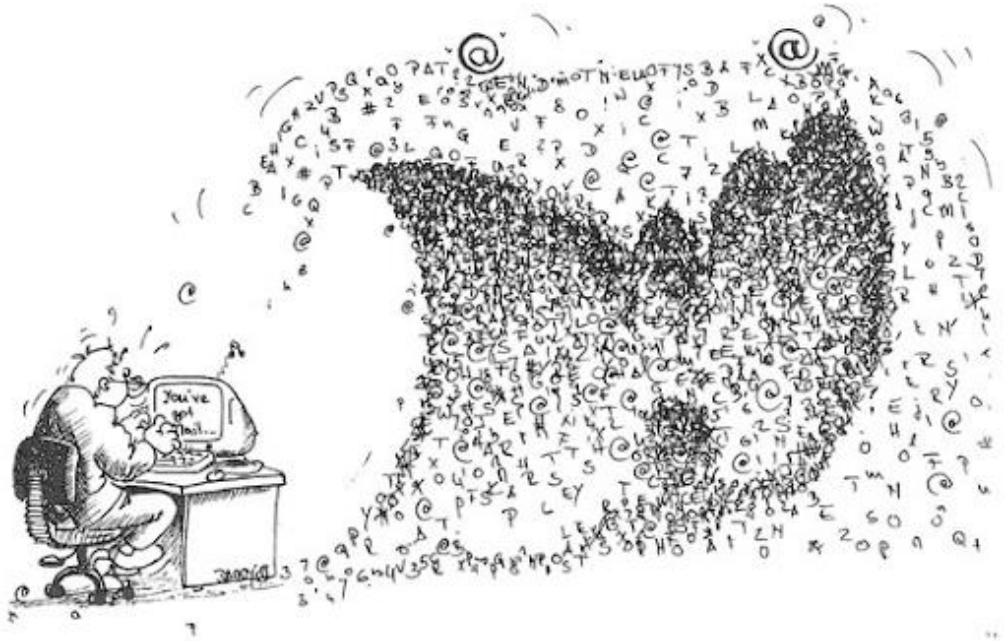
BRAIN IMAGING DATA STRUCTURE

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**

Gorgolewski, *Scientific Data*, 2016

What is BIDS?

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

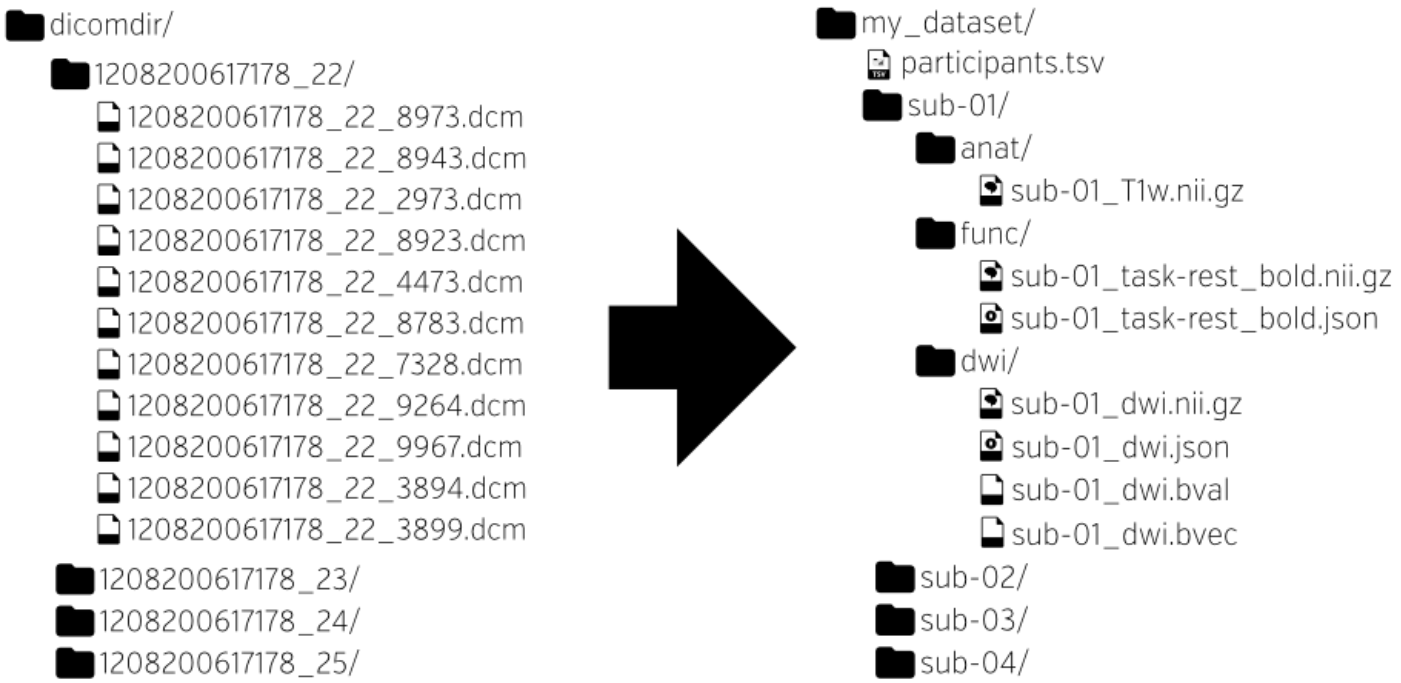
DATA STRUCTURE

- 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

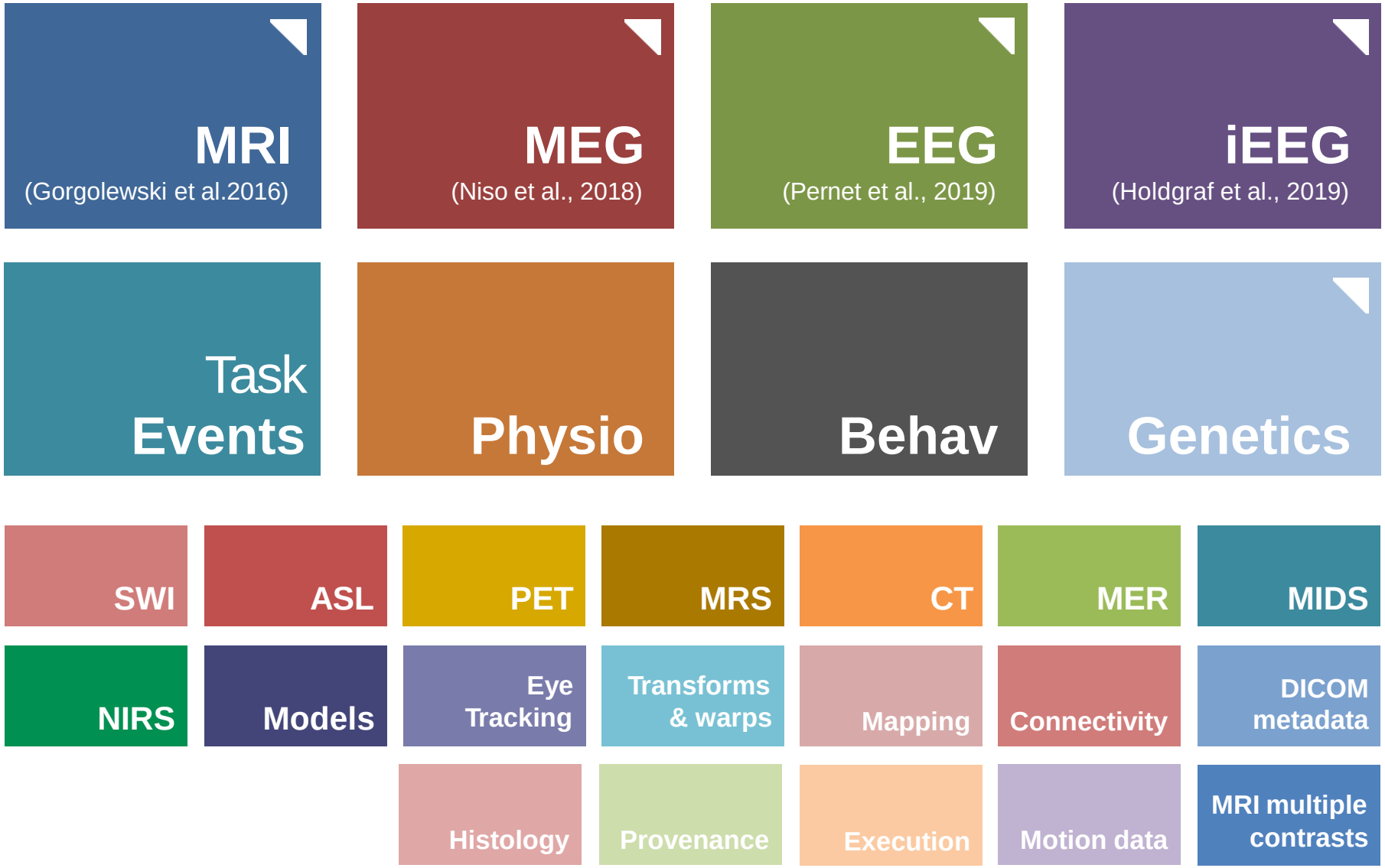


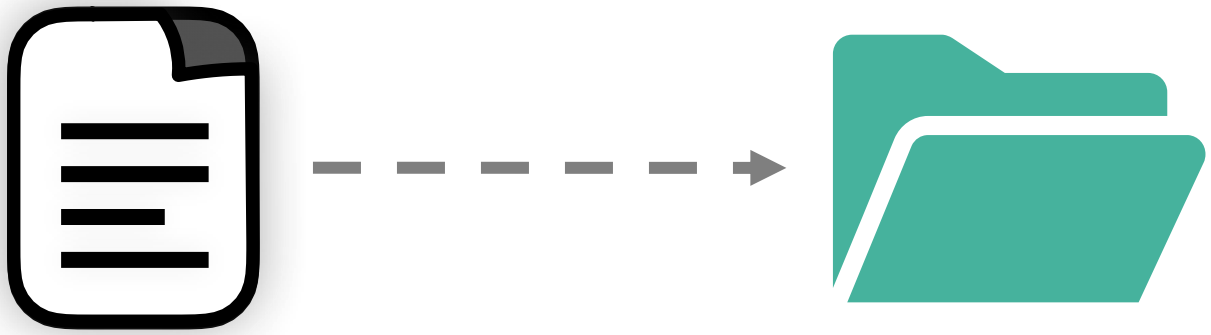
Adoption of a common standards to describe data and its organization **on disk**:

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

Gorgolewski, *Scientific Data*, 2016

BIDS universe





BIDS Specification

https://bids-specification.readthedocs.io

Where do we want to go?

Example1/

```
├─ 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).*
- [...]

https://bids-specification.readthedocs.io/en/stable/02-common-principles.html

Common principles

Level of requirement:

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

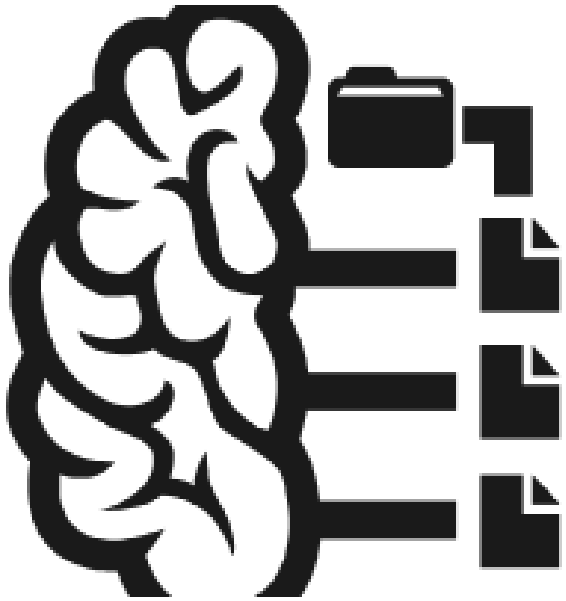
Inheritance principile

- 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
```

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



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

https://docs.google.com/document/d/1iaaLKgWjK5pcISD1MVxHKexB3PZWfE2aAC5HF_pCZWo/edit?usp=sharing

Metadata | motion.json

MUST

TaskName, MotionTrackedPoints, StartTime, TrackingSystem, SamplingFrequency

RECOMMENDED

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

OPTIONAL

Manufacuturer, 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,
}
}

https://docs.google.com/document/d/1iaaLKgWjK5pcISD1MVxHKexB3PZWfE2aAC5HF_pCZWo/edit?usp=sharing

Metadata | channels.tsv

MUST

name, tracked_point, tracking_system, type, [illegible], units

name	type	units	srate			ystem
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	y	
IMU1_lf_gyro_z	GYRO	rad/s	222	lf	z	1

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

A PREPRINT

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https://docs.google.com/document/d/1iaaLKgWjK5pcISD1MVxHKexB3PZWfE2aAC5HF_pCZWo/edit?usp=sharing

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
…	…	…	…	…	…

https://docs.google.com/document/d/1iaaLKgWjK5pcISD1MVxHKexB3PZWfE2aAC5HF_pCZWo/edit?usp=sharing

Metadata | modality specific - motion

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
...	...	...	...	...	...

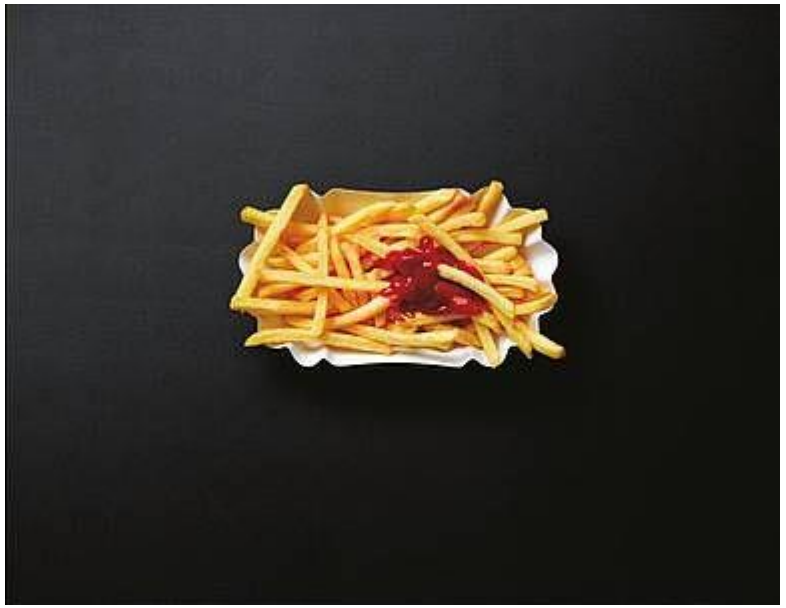

```
{
"TaskName": "BIDS Motion fictive example",
"TaskDescription": „Running around",
„StartTime": „ 2019-06-15T13:45:30 ",
"RecordingDuration": 4667.641106,
"TrackingSystemCount" : 1,
"MotionTrackedPoints" : 1,
"MotionChannelCount": 6,
"TrackingSystems":{

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


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

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

https://docs.google.com/document/d/1iaaLKgWjK5pcISD1MVxHKexB3PZWfE2aAC5HF_pCZWo/edit?usp=sharing

Conclusions



BIDS
BRAIN IMAGING DATA STRUCTURE

Conclusions

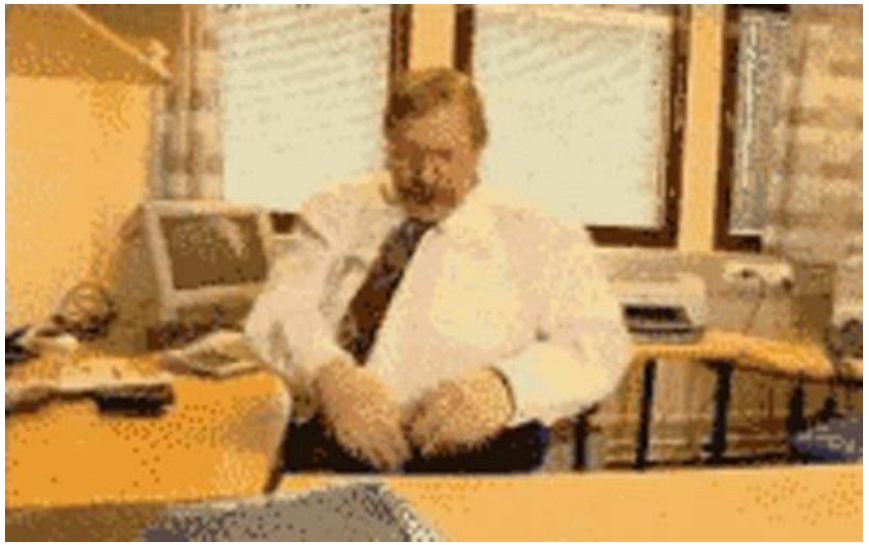
Example1/

```
├─ 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
```

REDCap
Research Electronic Data Capture

python™

MATLAB®



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`