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## BIDS-Prov: Recording neuroimaging provenance

Camille Maumet

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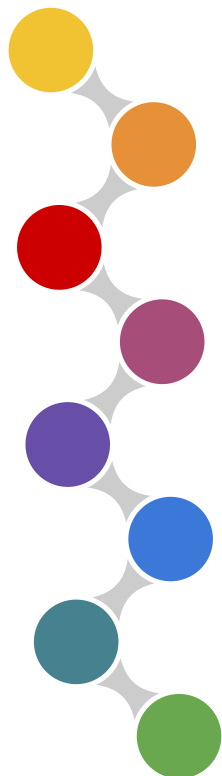
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Workshop BIDS-derivatives  
June 21-23, 2023



# BIDS-Prov

Recording neuroimaging provenance

Camille Maumet

Inria, Univ Rennes, Inserm, CNRS, IRISA



# The BIDS-Prov Team

## BIDS Extension Proposal 28

**Moderators:** Satra Ghosh and Camille Maumet

**Contributors:** Rémi Adon, Tibor Auer, Stefan Appelhoff, Thomas Betton, Hermann Courteille, Michael Dayan, Eric Earl, Dorota Jarecka, Yaroslav Halchenko, Matthieu Joulot, Chris Markiewicz, Cyril R. Pernet, Jean-Baptiste Poline, Cyril Regan, Omar El Rifai, Sarah Saneei, Ghislain Vaillant.

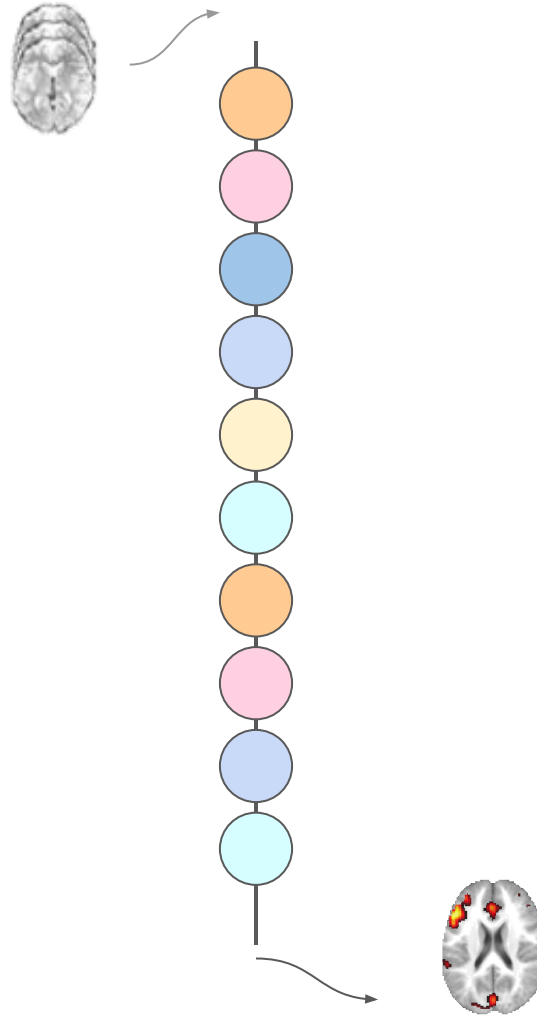
Thank you!



**BIDS steering committee:** Guiomar Niso, Melanie Ganz, Robert Oostenveld, Russell Poldrack, Ariel Rokem.

**BIDS maintainers:** Stefan Appelhoff, Chris Markiewicz, Franklin Feingold, Taylor Salo, Rémi Gau, Ross Blair, Anthony Galassi, Eric Earl, Christine Rogers.

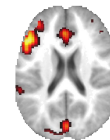
# What is **BIDS-Prov**?



# What is **BIDS-Prov**?

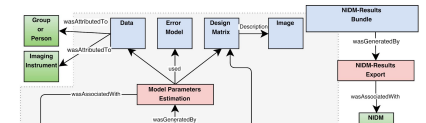
```
my_dataset/  
├── participants.tsv  
├── sub-01/  
│   ├── anat/  
│   │   └── sub-01_T1w.nii.gz  
│   └── func/
```

**BIDS**  
“raw”

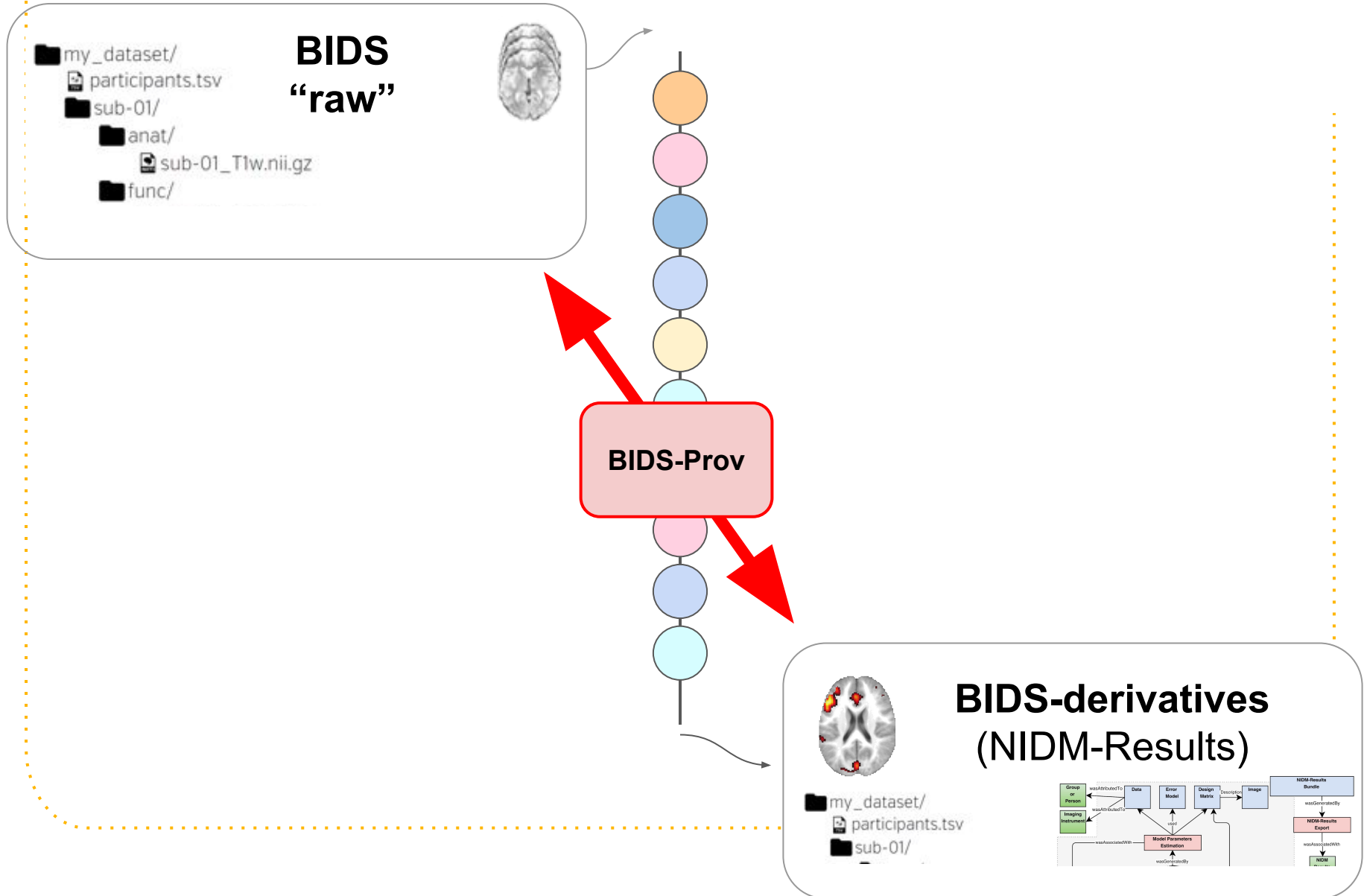


**BIDS-derivatives**  
(NIDM-Results)

```
my_dataset/  
├── participants.tsv  
└── sub-01/
```



# What is **BIDS-Prov**?



# Goal of BIDS-Prov

- Describing **the provenance** of a BIDS dataset.
- Description is **retrospective**,  
i.e. set of steps that were executed in order to obtain the dataset.

# Why BIDS-Prov?

- BIDS focus on metadata that will maximize the **(re)usability** of datasets
  - E.g. onsets for task-fMRI
- Relies on expert knowledge to identify metadata that “matter”
- But for derived datasets this can get complicated...

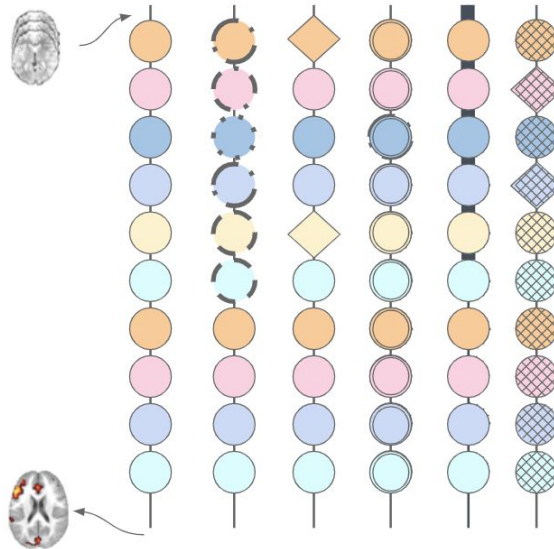


# What is a reusable derived dataset?

- **Can depend on the software package** (different stopping points) → Paul
- We sometimes **lack expert knowledge** to identify metadata that “matter” in neuroimaging pipelines

# Understanding analytical variability...

?



# Understanding analytical variability...

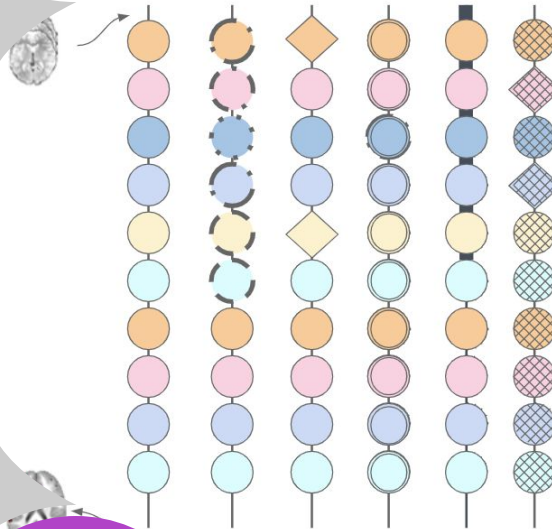
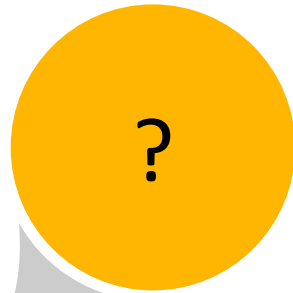
[Glatard 2015,  
Kiar 2021]

Numerical  
uncertainty  
(e.g.  $\neq$  OS)

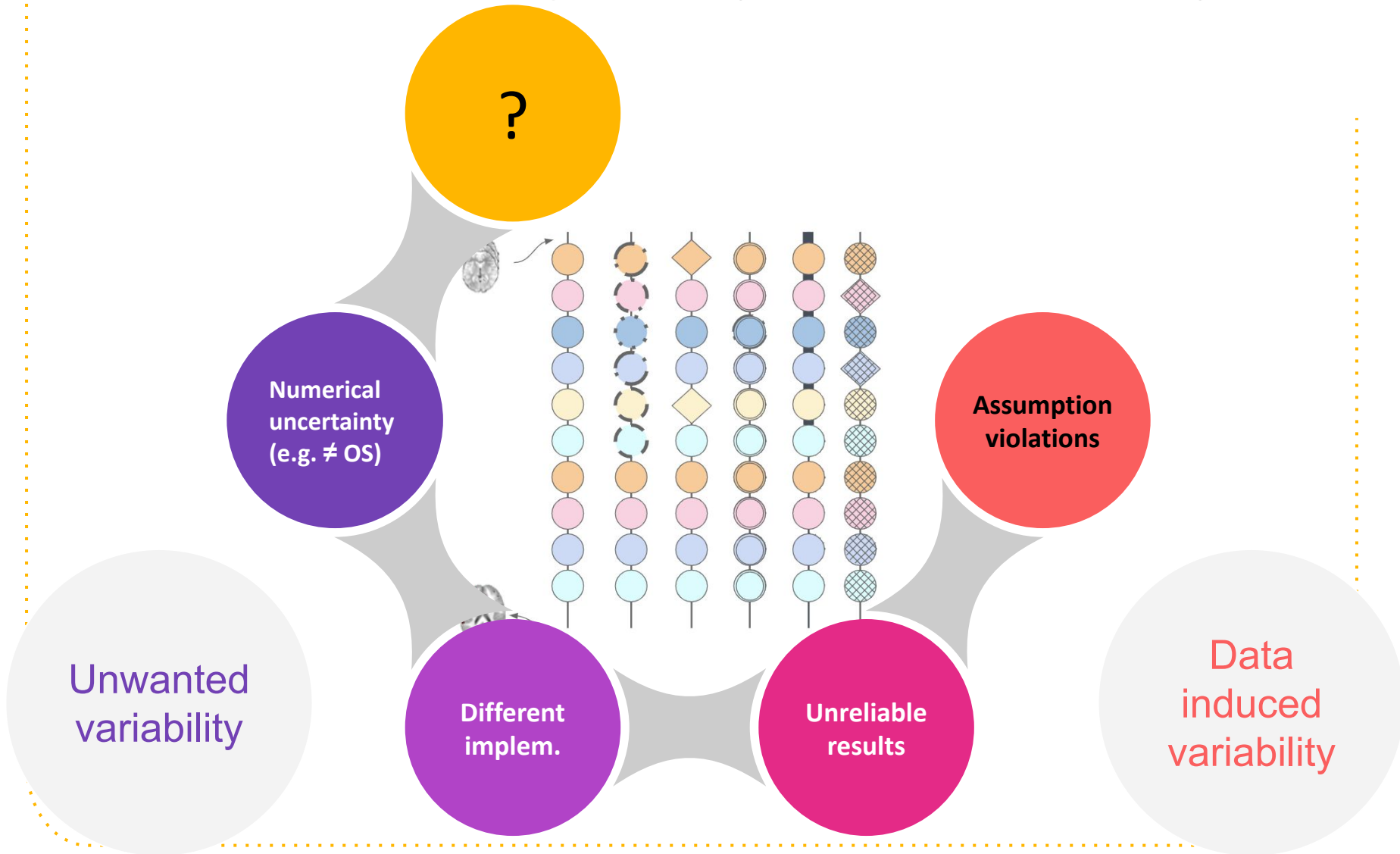
Unwanted  
variability

Different  
implem.

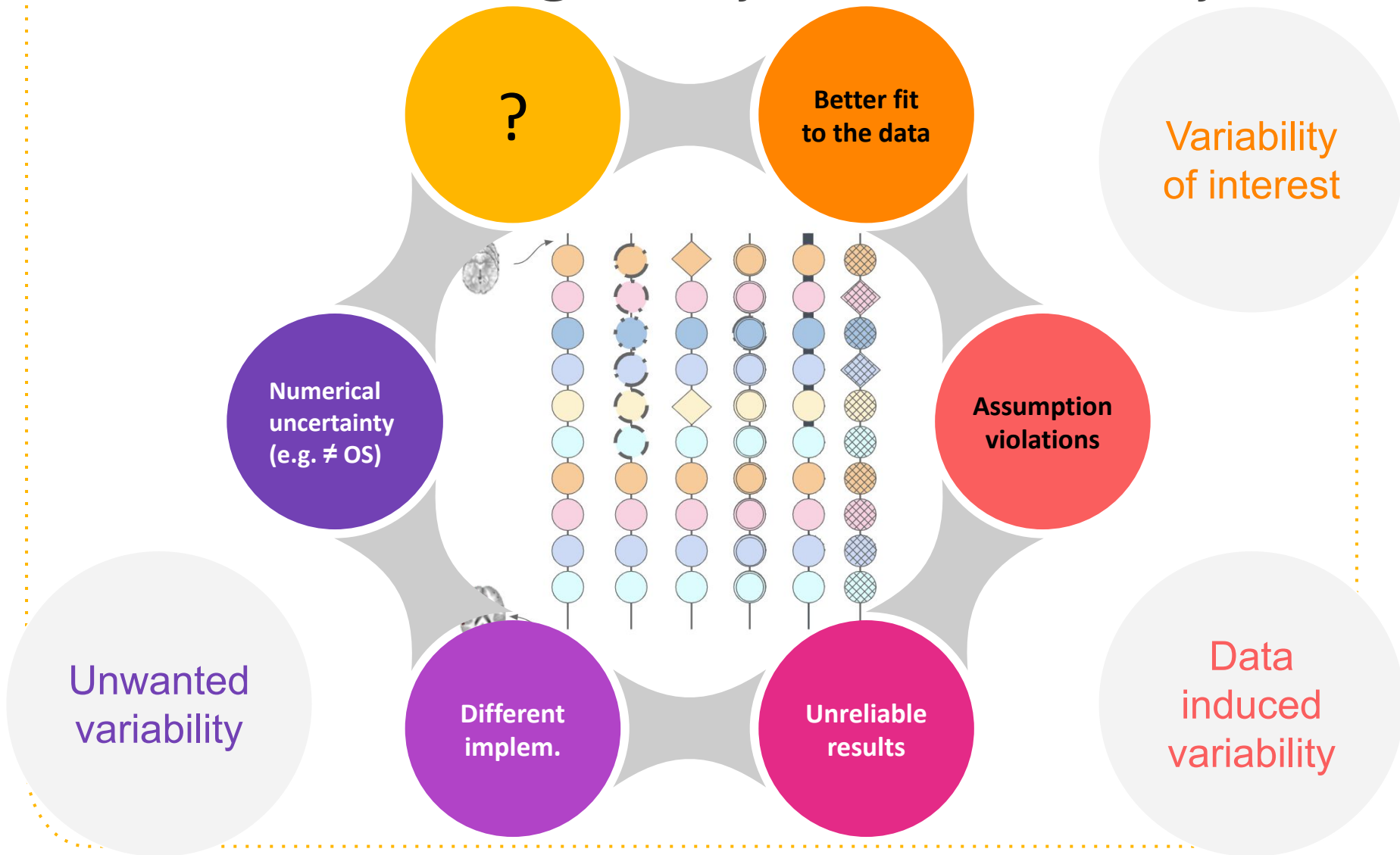
[Gronenschild 2012,  
Bowring 2019]



# Understanding analytical variability...



# Understanding analytical variability...



# What is a reusable derived dataset?

- **Can depend on the software package** (different stopping points) → Paul
- We sometimes **lack expert knowledge** to identify metadata that “matter” in neuroimaging pipelines
- **Expert knowledge can evolve** and in that case it is really useful to be able and go back to previous studies.

# What is a reusable derived dataset?

- **Can depend on the software package** (different stopping points) → Paul
- We sometimes **lack expert knowledge** to identify metadata that “matter” in neuroimaging pipelines
- **Expert knowledge can evolve** and in that case it is really useful to be able and go back to previous studies.

We need detailed description of "what happened" to a dataset (i.e. provenance)

# Provenance in neuroimaging software

- **AFNI history** is stored in the BRIK files
- **MINC** also has a mechanism to store provenance
- SPM stores some provenance in the **SPM.mat**, saving the **matlabbatch** as a batch script is also provenance.
- Similarly in FSL with the **fsf** files.

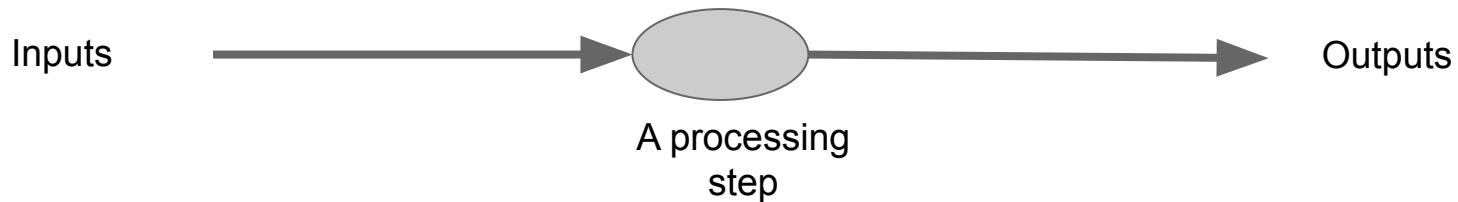
BIDS-Prov = an attempt at a software agnostic representation



# BIDS-Prov extension proposal

Key idea:

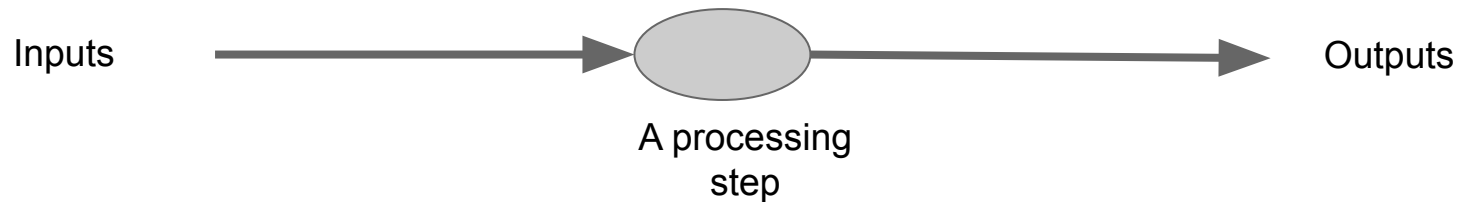
A common model to represent **chaining of processing** (for now no description of the 'meaning' of those processing)



# BIDS-Prov extension proposal

Key idea:

A common model to represent **chaining of processing** (for now no description of the 'meaning' of those processing)



BIDS-Prov files can be stored at two-levels:

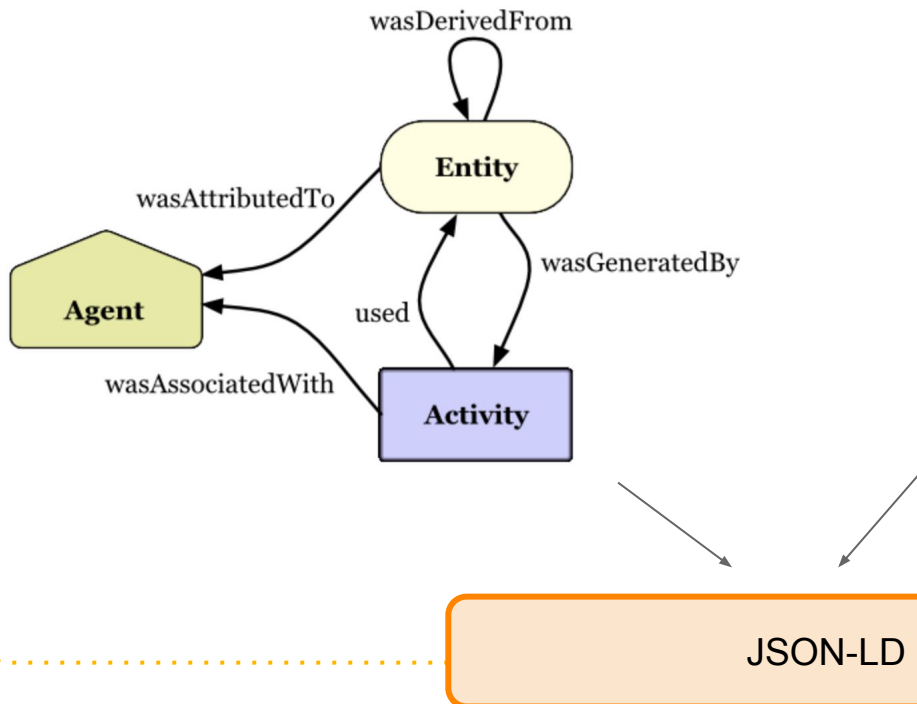
- File-level provenance `<path-to-file><file-name-with-ext>.prov.jsonld`
- Dataset-level provenance `prov/[<subfolders>*/]<label>.prov.jsonld`

# BIDS-Prov extension proposal

## RDF

BIDS-Prov uses semantic web technologies and is based on the **W3C PROV**

## BIDS



# Example

```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
  "BIDSProvVersion": "dev",
  "records": {
    "prov:Agent": [
      { "@id": "urn:030f431e-c8bd-4ad2-a374-1f115df2930e",
        "RRID": "RRID:SCR_007037",
        "@type": "prov:SoftwareAgent",
        "label": "SPM",
        "version": "SPM12r7224" }
    ],
    "prov:Activity": [
      { "@id": "urn:d124a1ec-ede9-4c55-9f3b-5534ba2d4bf1",
        "label": "Segment",
        "used": [
          "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6"
        ],
        "associatedWith": "urn:030f431e-c8bd-4ad2-a374-1f115df2930e",
        "command": "matlabbatch{7}.spm.spatial.preproc.channel.vols(1) = [...] }
    ],
    "prov:Entity": [
      { "@id": "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6",
        "label": "anat_sub-01_T1w.nii",
        "generatedBy": "urn:771015e0-2dcd-4c90-b82f-1910bff41ca0" }
    ]
  }
}
```

# Example

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{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
  "BIDSProvVersion": "dev",
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    "prov:Agent": [
      { "@id": "urn:030f431e-c8bd-4ad2-a374-1f115df2930e",
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        ],
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# Example

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```

Software used

# Example

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  "records": {
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Software used

SPM

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```

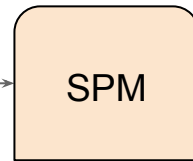
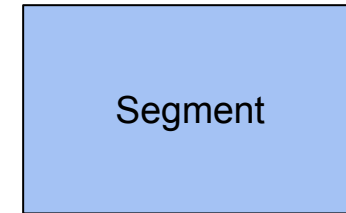
Processing  
applied ("steps")

SPM



# Example

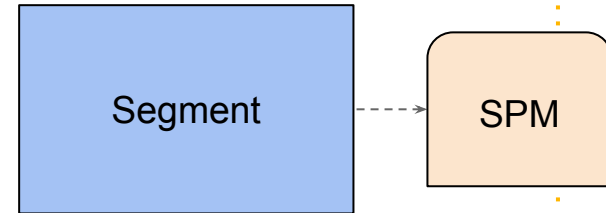
```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
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        "generatedBy": "urn:771015e0-2dcd-4c90-b82f-1910bff41ca0"}
    ]
  }
}
```



Processing  
applied ("steps")

# Example

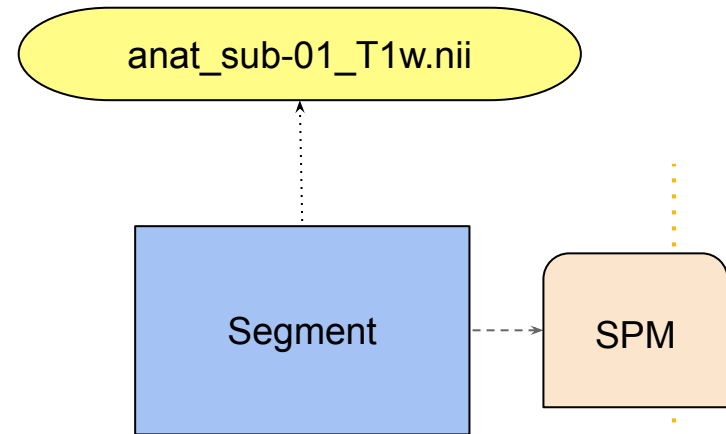
```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
  "BIDSProvVersion": "dev",
  "records": {
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        "generatedBy": "urn:771015e0-2dcd-4c90-b82f-1910bff41ca0" }
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```



Inputs and  
outputs

# Example

```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
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```



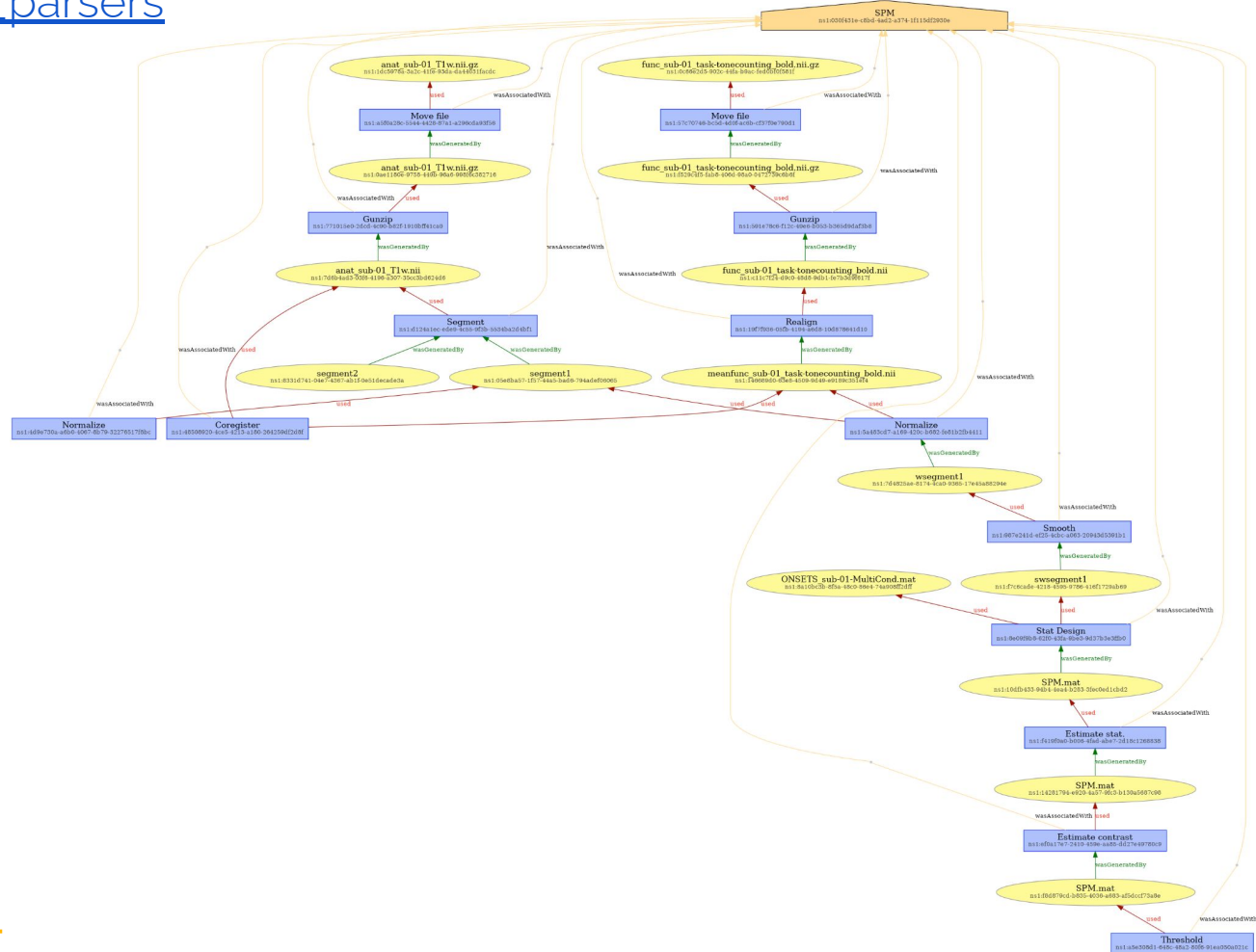
Inputs and  
outputs

# Real world examples

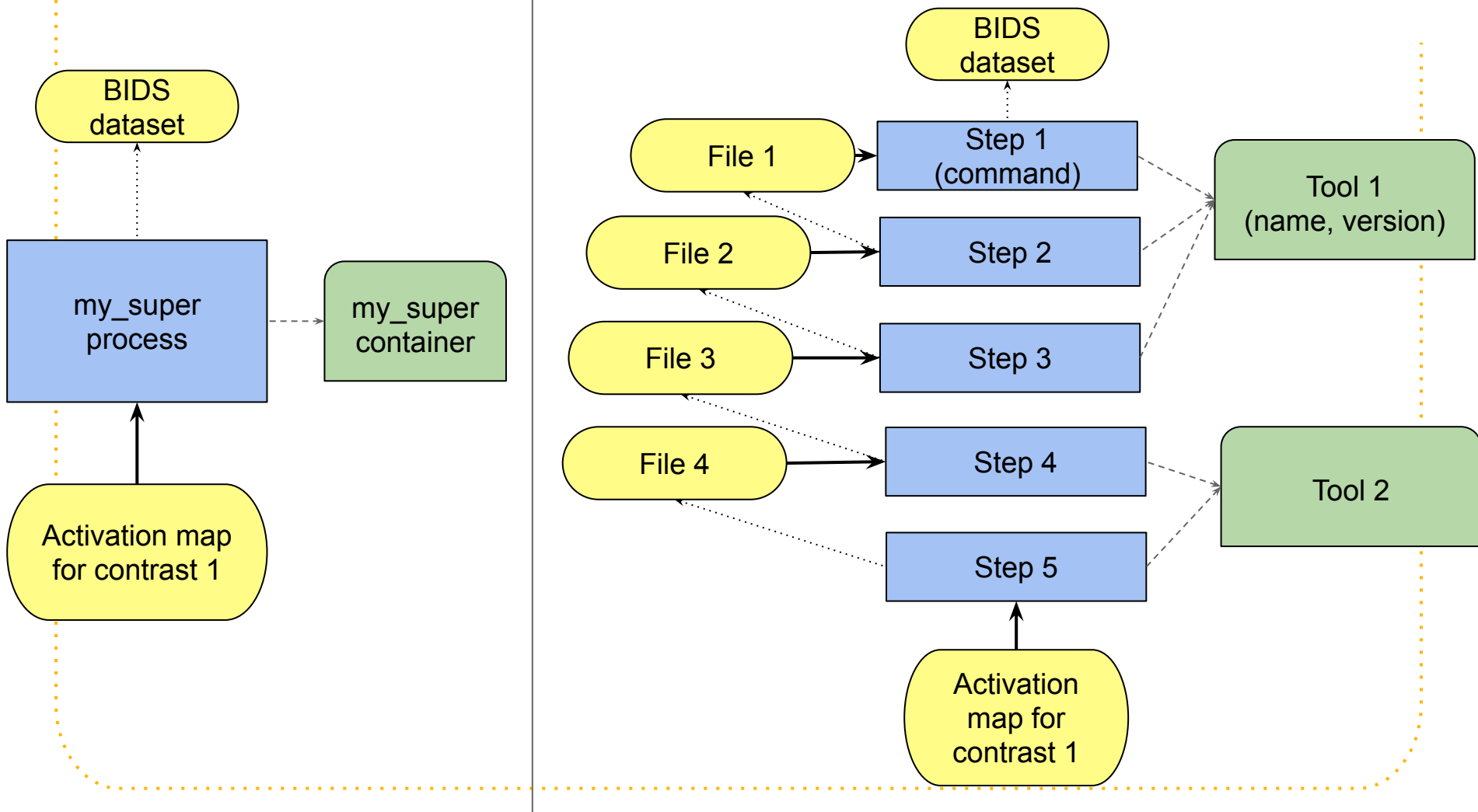
[https://github.com/bids-standard/BEPo28\\_BIDSprov/tree/master/examples/from\\_parsers](https://github.com/bids-standard/BEPo28_BIDSprov/tree/master/examples/from_parsers)

50+ examples in

- AFNI
- FSL
- SPM

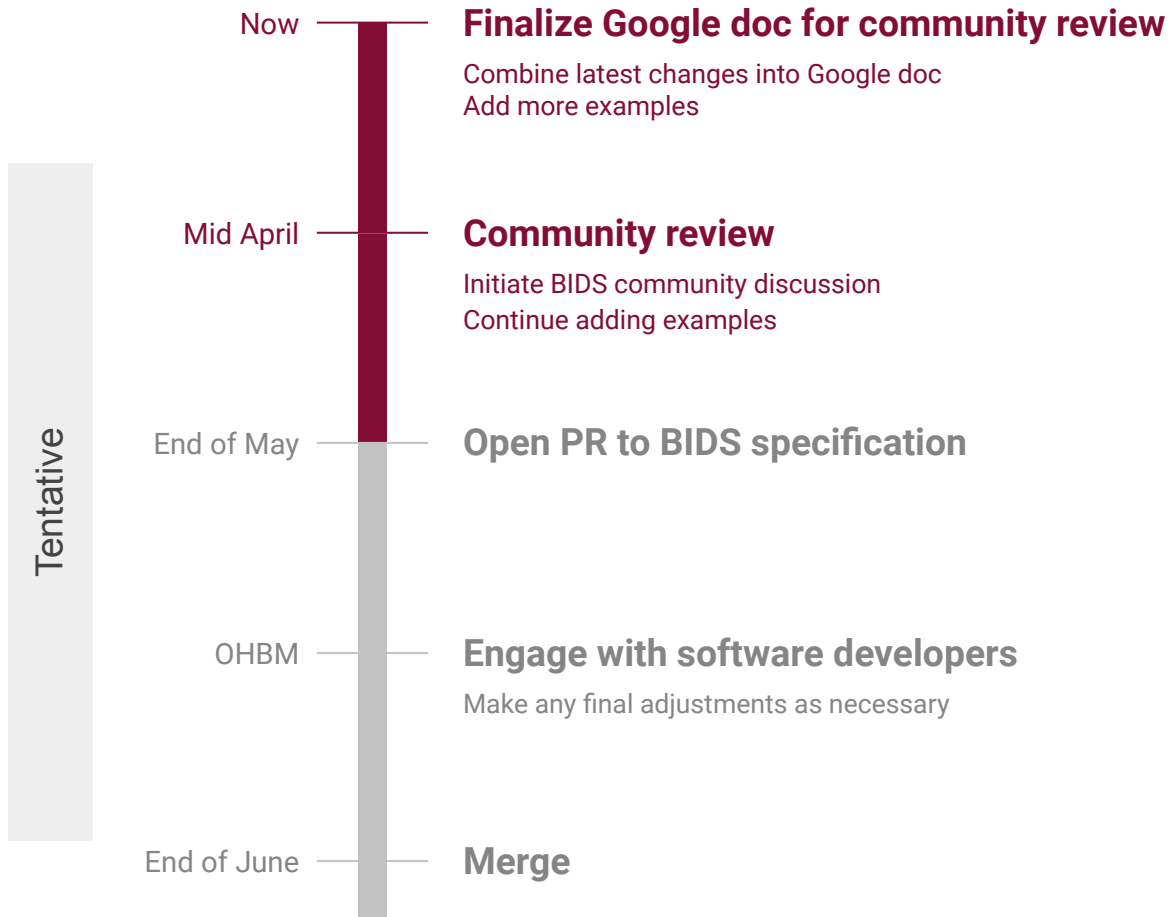


# Different "levels" of provenance



# Timeline and next steps

Presented to  
BIDS steering in  
March 2022



# BIDS-Prov extension proposal

**BIDS-Prov adds provenance information to the BIDS structure** in the form of sidecar JSON-LD files, which constitute a graph of provenance information.

Open questions / thoughts:

- Some provenance is already in BIDS
- Different levels of provenance will enable different use cases
- Ability to keep track of provenance might depend on the application and the context (which metadata is available)
- Satra : Possibility to implement via message passing

Workshop BIDS-derivatives  
June 21-23, 2023



# BIDS-Prov

Recording neuroimaging provenance

Camille Maumet



# Thank you!



[@cmaumet@fediscience.org](mailto:cmaumet@fediscience.org)

Credit: Presentation template and icons by SlidesCarnival, adapted



[@cmaumet](https://twitter.com/cmaumet)