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BIDS-Prov: Recording neuroimaging provenance

Camille Maumet

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Submitted on 22 Jun 2023

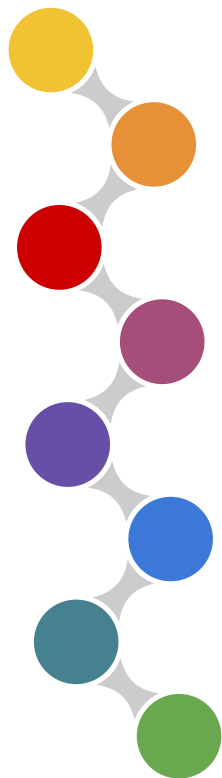
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Workshop BIDS-derivatives
June 21-23, 2023



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.

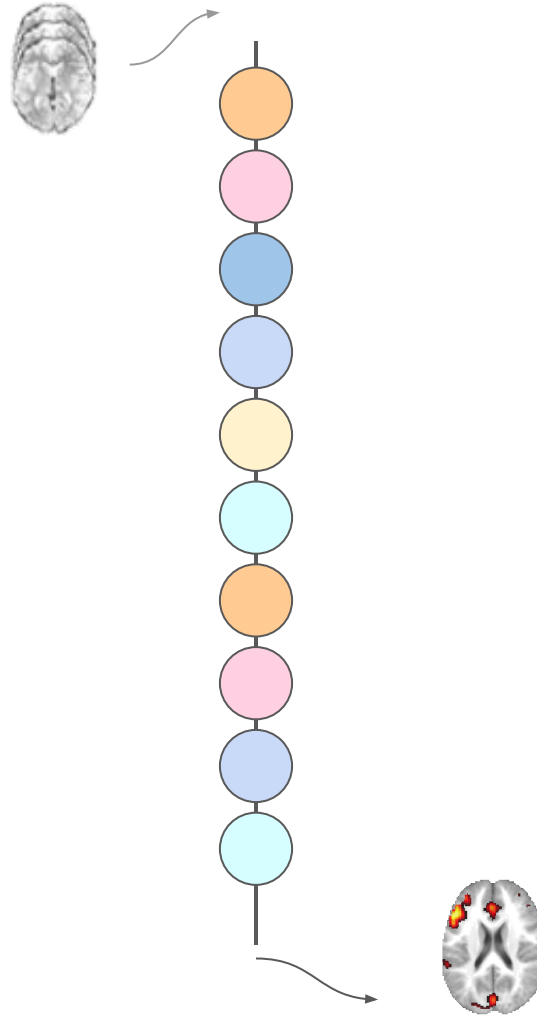
Thank you!



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.

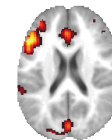
What is **BIDS-Prov**?



What is **BIDS-Prov**?

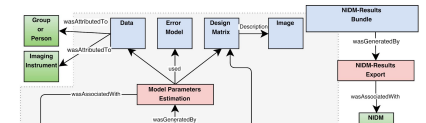
```
my_dataset/  
├── participants.tsv  
├── sub-01/  
│   ├── anat/  
│   │   └── sub-01_T1w.nii.gz  
│   └── func/
```

BIDS
“raw”

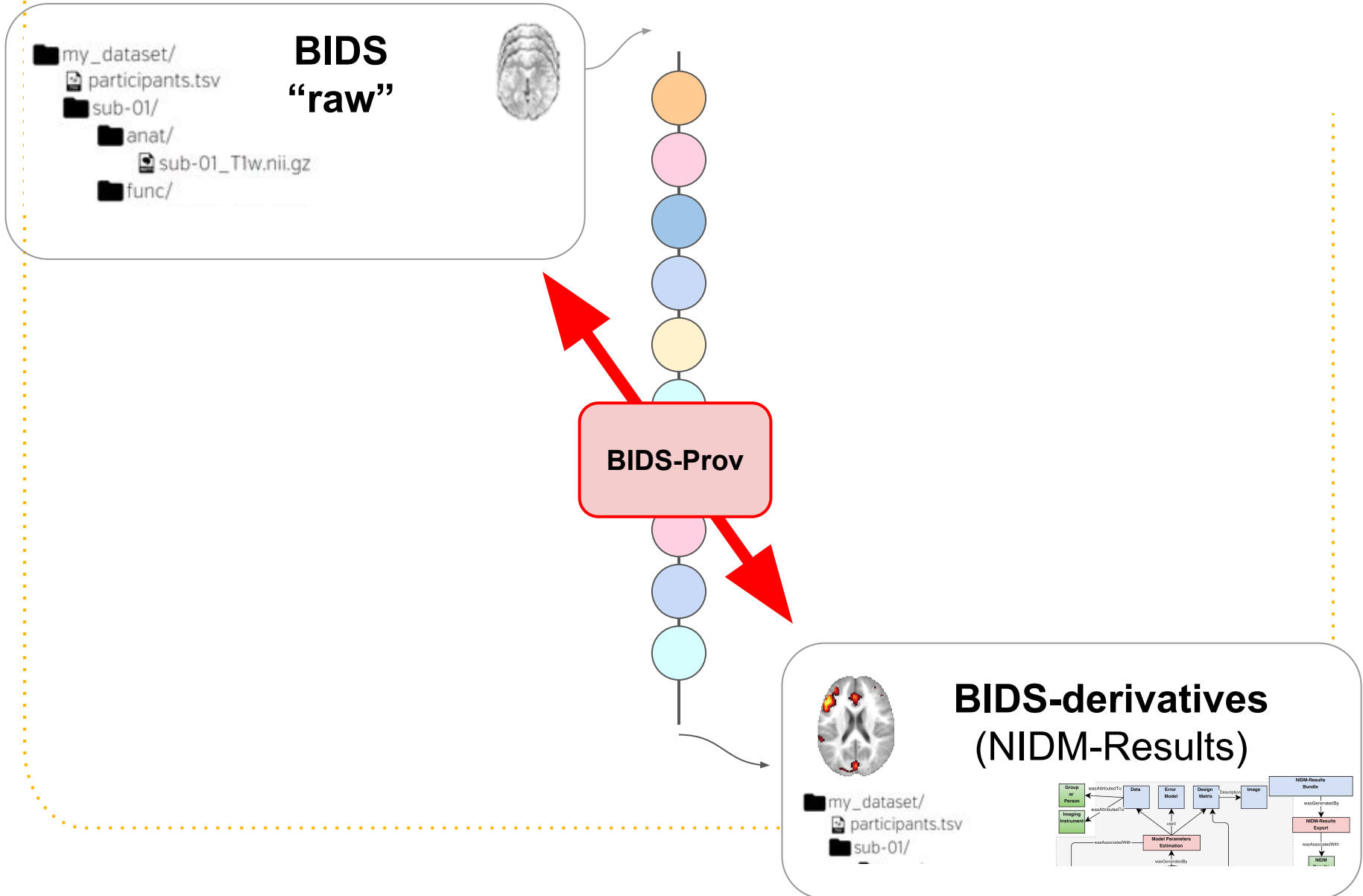


BIDS-derivatives
(NIDM-Results)

```
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?

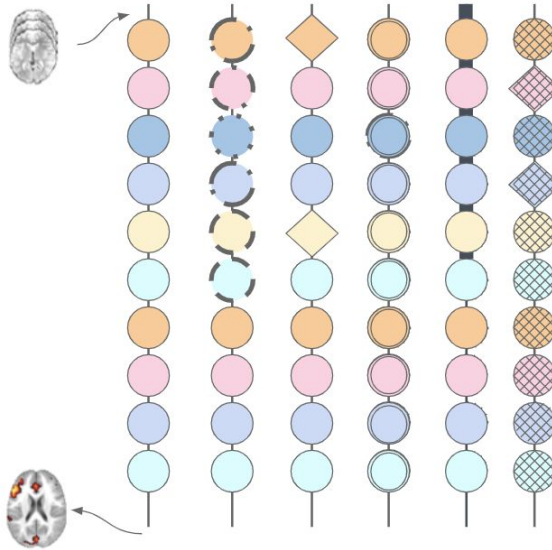
- BIDS focus on metadata that will maximize the **(re)usability** of datasets
 - E.g. onsets for task-fMRI
- Relies on expert knowledge to identify metadata that “matter”
- But for derived datasets this can get complicated...

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...

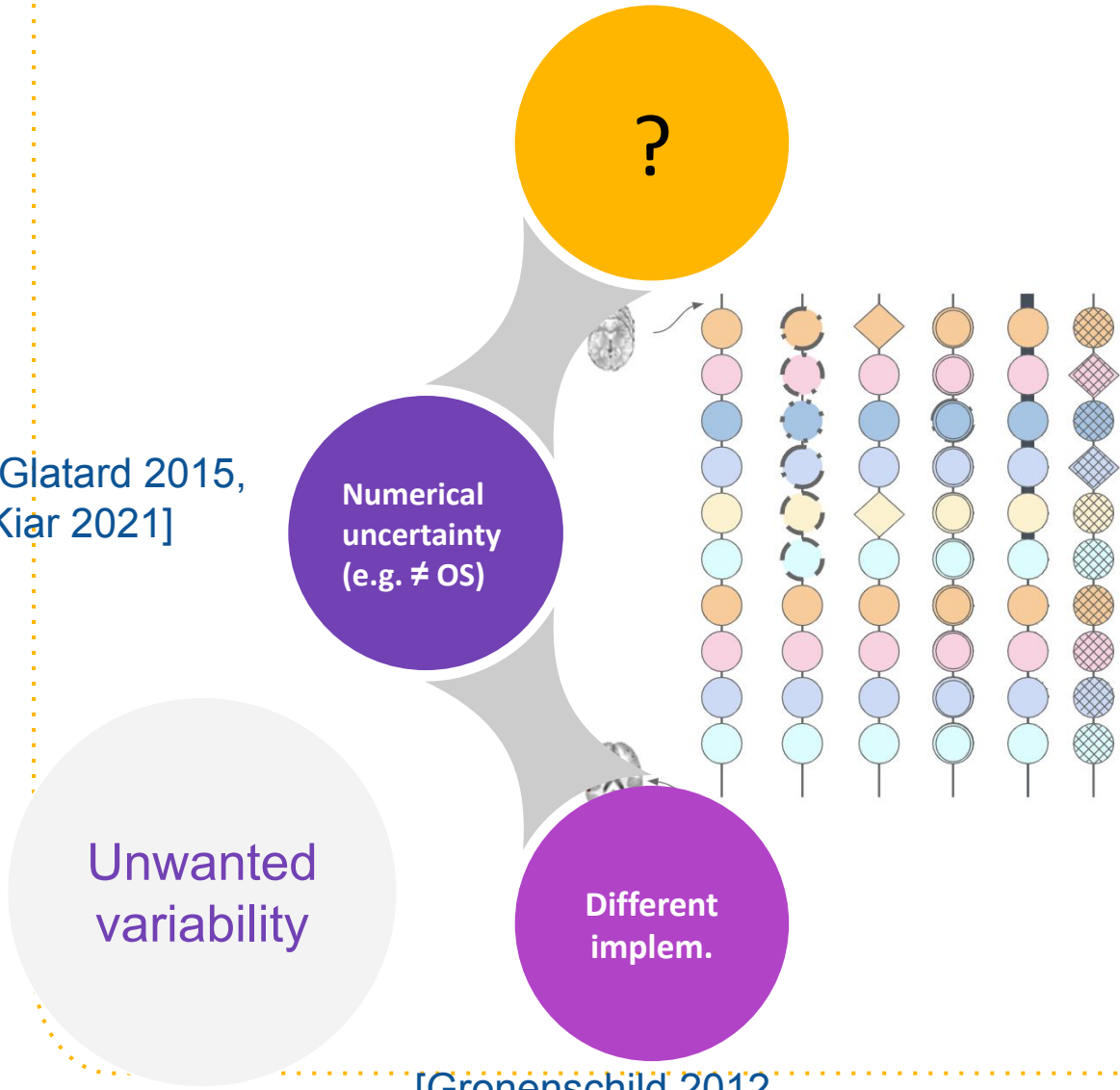
[Glatard 2015,
Kiar 2021]

Numerical
uncertainty
(e.g. \neq OS)

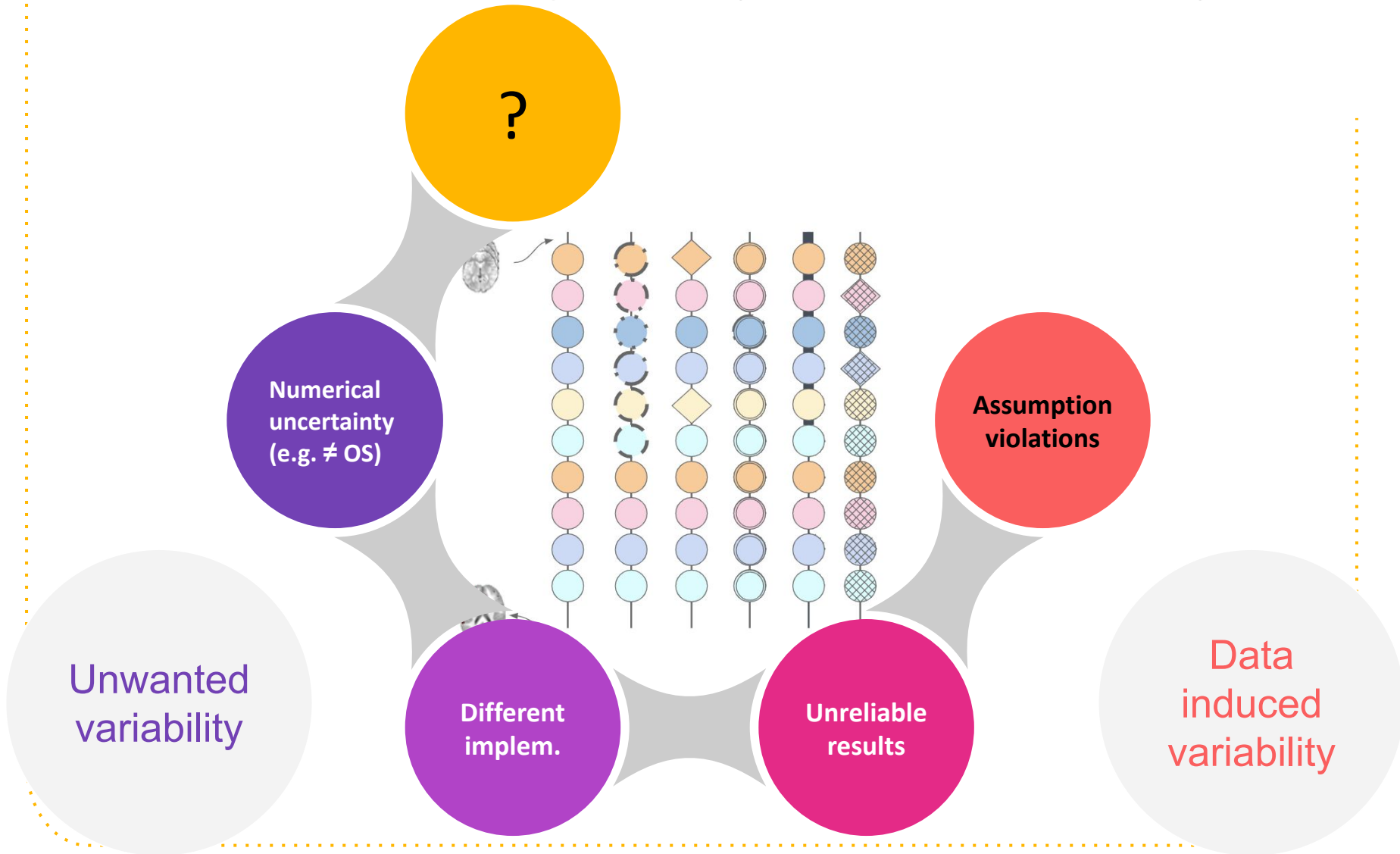
Unwanted
variability

Different
implem.

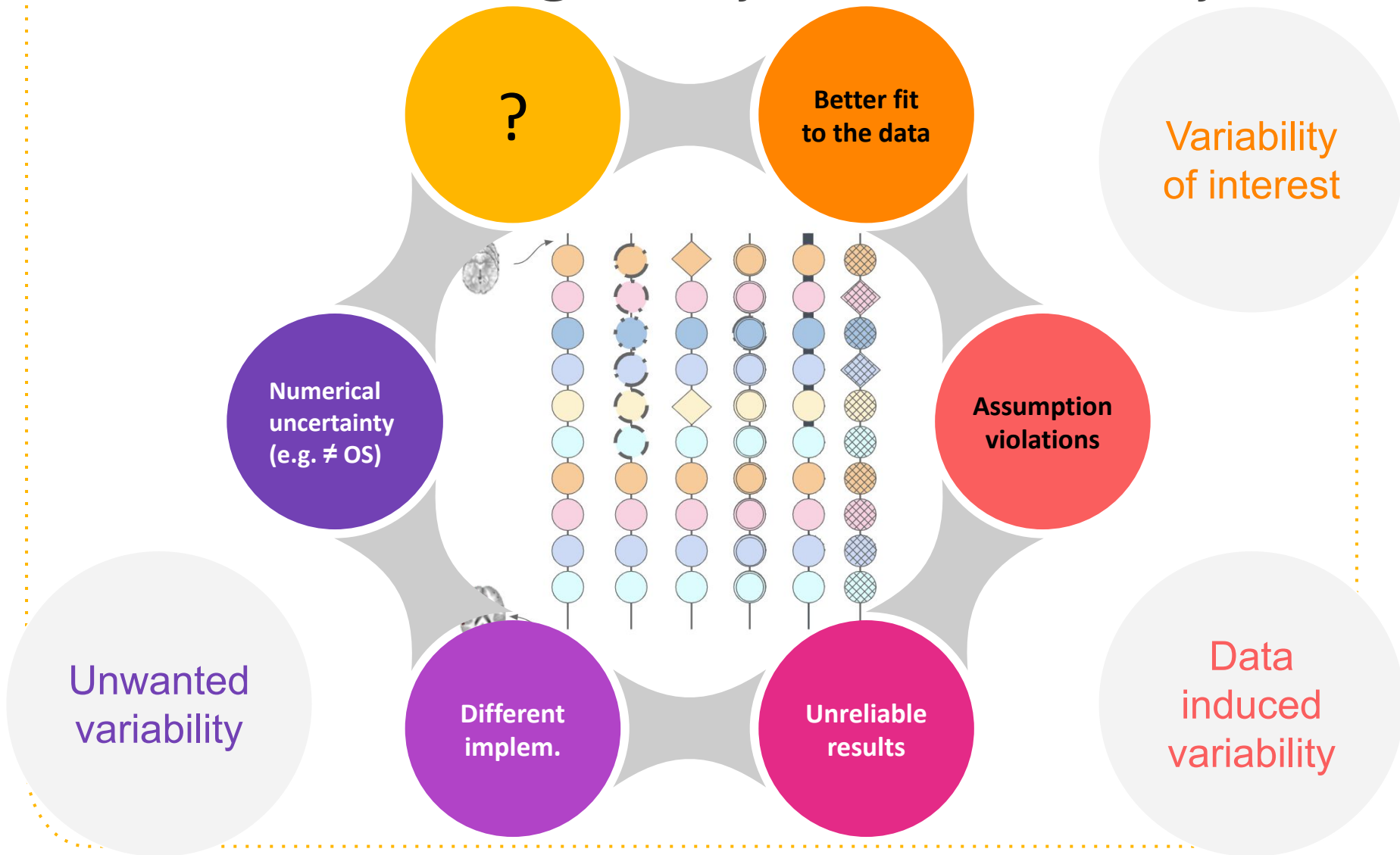
[Gronenschild 2012,
Bowring 2019]



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

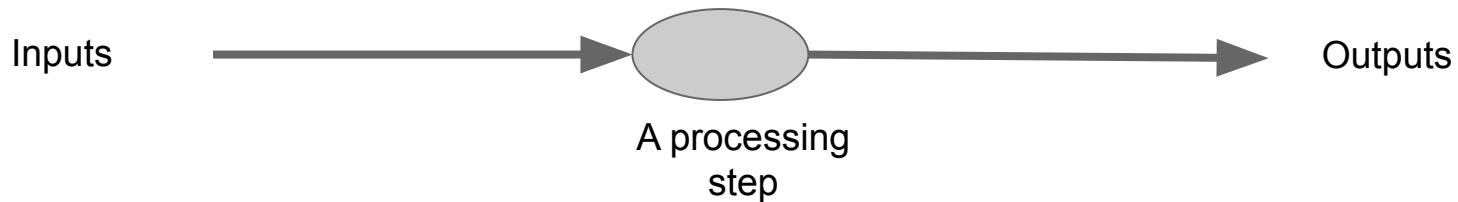
- **AFNI history** is stored in the BRIK files
- **MINC** also has a mechanism to store provenance
- SPM stores some provenance in the **SPM.mat**, saving the **matlabbatch** as a batch script is also provenance.
- Similarly in FSL with the **fsf** files.

BIDS-Prov = an attempt at a software agnostic representation

BIDS-Prov extension proposal

Key idea:

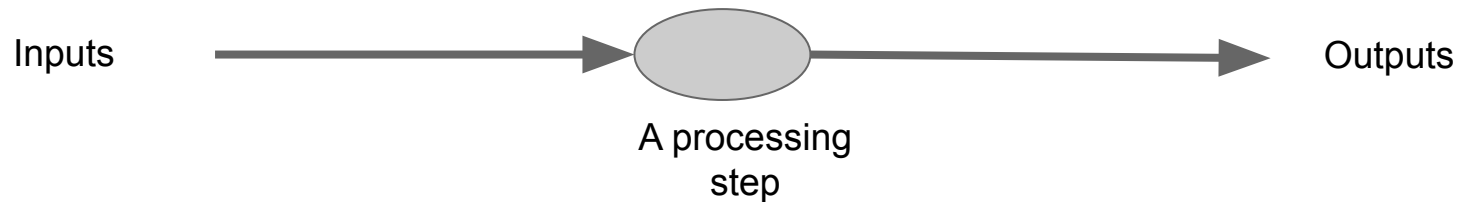
A common model to represent **chaining of processing** (for now no description of the 'meaning' of those processing)



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:

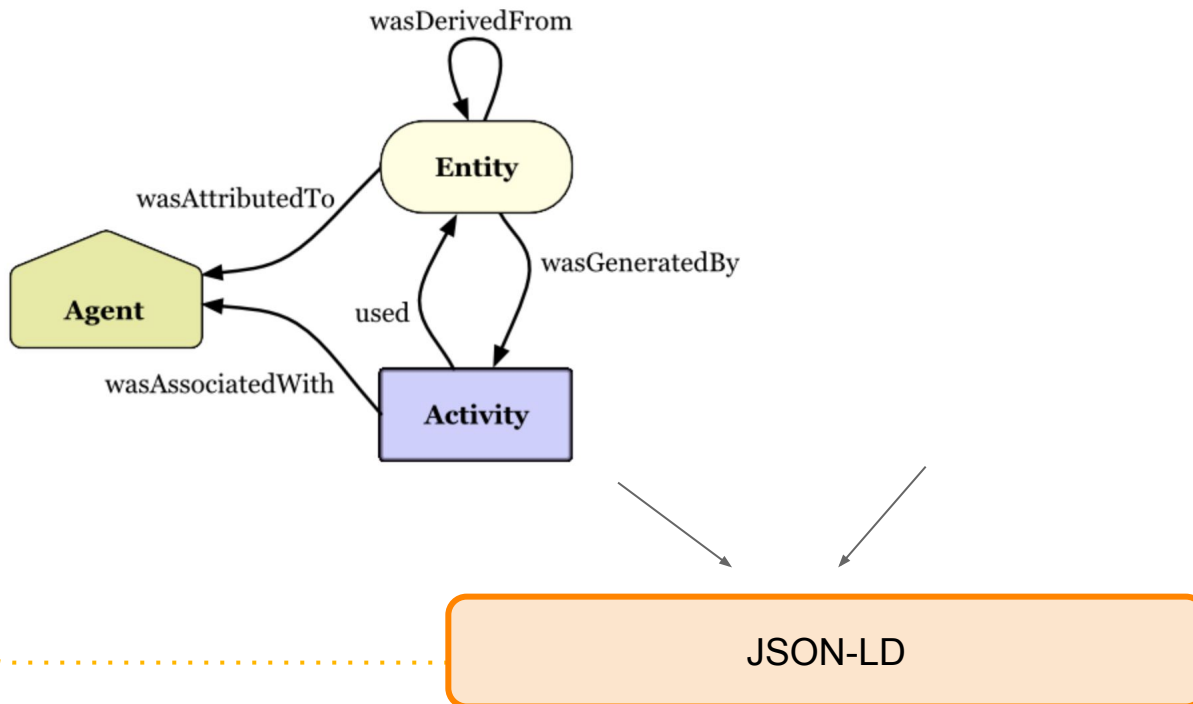
- File-level provenance `<path-to-file><file-name-with-ext>.prov.jsonld`
- Dataset-level provenance `prov/[<subfolders>*/]<label>.prov.jsonld`

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": [
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      { "@id": "urn:d124a1ec-ede9-4c55-9f3b-5534ba2d4bf1",
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Example

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        "label": "Segment",
        "used": [
          "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6"
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        "associatedWith": "urn:030f431e-c8bd-4ad2-a374-1f115df2930e",
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    ]
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```

Software used

Example

```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
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    "prov:Agent": [
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        "command": "matlabbatch{7}.spm.spatial.preproc.channel.vols(1) = [...] }
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      { "@id": "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6",
        "label": "anat_sub-01_T1w.nii",
        "generatedBy": "urn:771015e0-2dcd-4c90-b82f-1910bff41ca0" }
    ]
  }
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```

Software used

SPM

Example

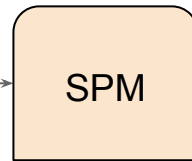
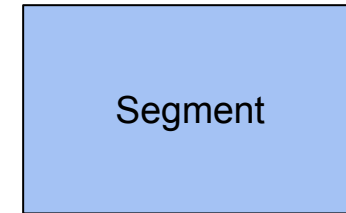
```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
  "BIDSProvVersion": "dev",
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      { "@id": "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6",
        "label": "anat_sub-01_T1w.nii",
        "generatedBy": "urn:771015e0-2dcd-4c90-b82f-1910bff41ca0" }
    ]
  }
}
```

Processing
applied ("steps")

SPM

Example

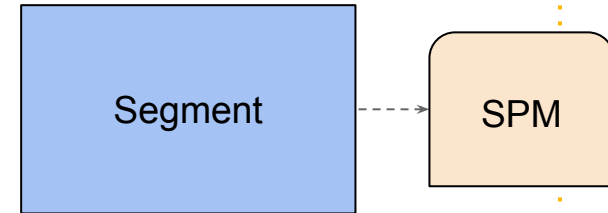
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{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
  "BIDSProvVersion": "dev",
  "records": {
    "prov:Agent": [
      {"@id": "urn:030f431e-c8bd-4ad2-a374-1f115df2930e",
        "RRID": "RRID:SCR_007037",
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        "used": [
          "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6"
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        "label": "anat_sub-01_T1w.nii",
        "generatedBy": "urn:771015e0-2dcd-4c90-b82f-1910bff41ca0"}
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  }
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Processing
applied ("steps")

Example

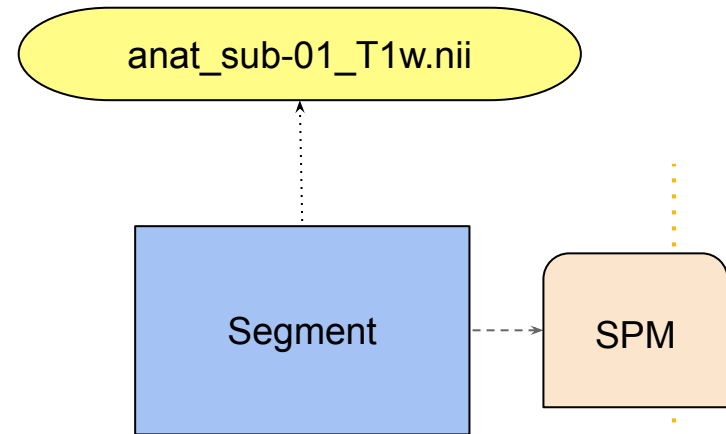
```
{ "@context": "https://raw.githubusercontent.com/bids-standard/BEP028_BIDSprov/master/context.json",
  "BIDSProvVersion": "dev",
  "records": {
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          "urn:7d6b4ad3-03f6-4196-a307-35cc3bd624d6"
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        "command": "matlabbatch{7}.spm.spatial.preproc.channel.vols(1) = [...] }
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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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  "records": {
    "prov:Agent": [
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    ]
  }
}
```



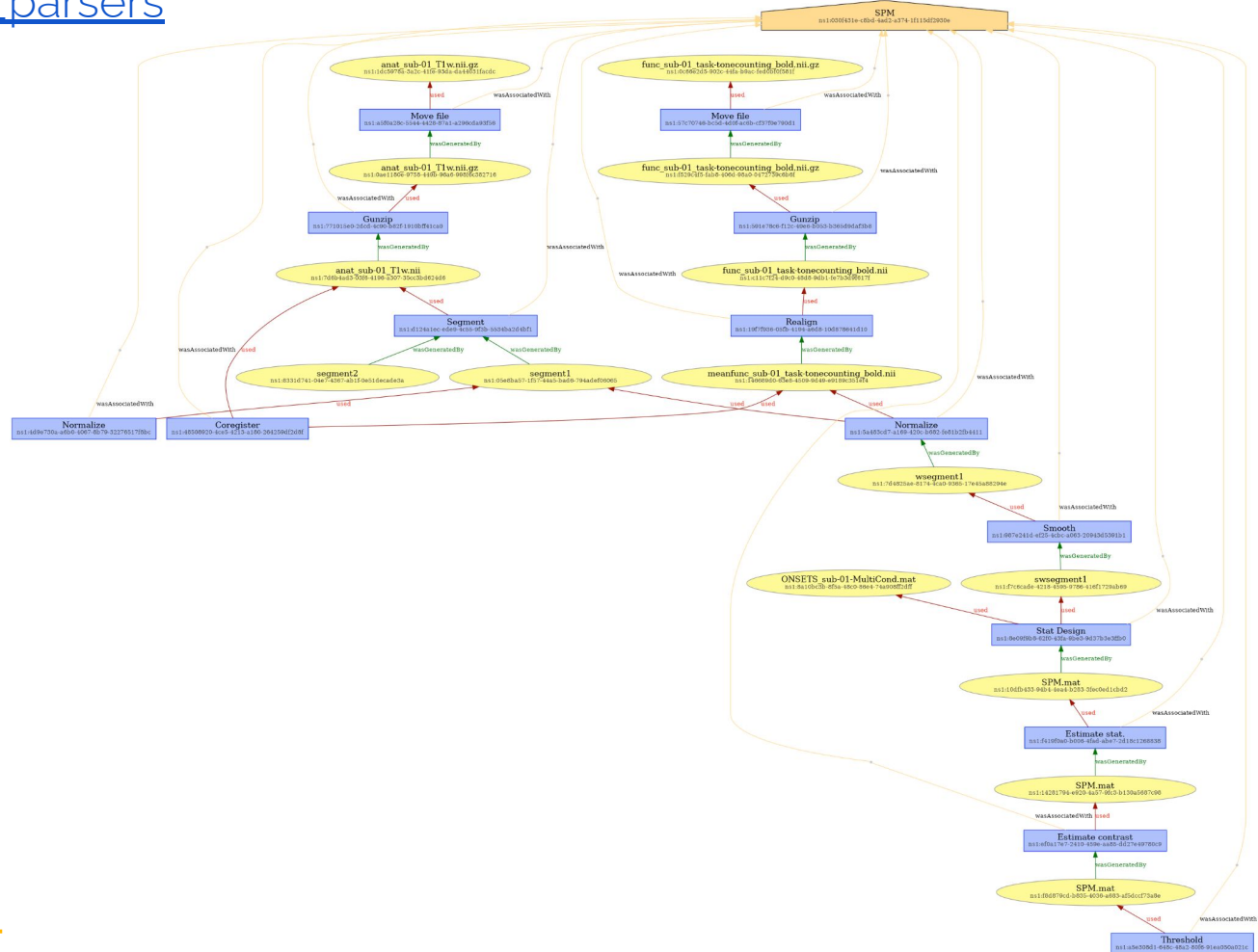
Inputs and
outputs

Real world examples

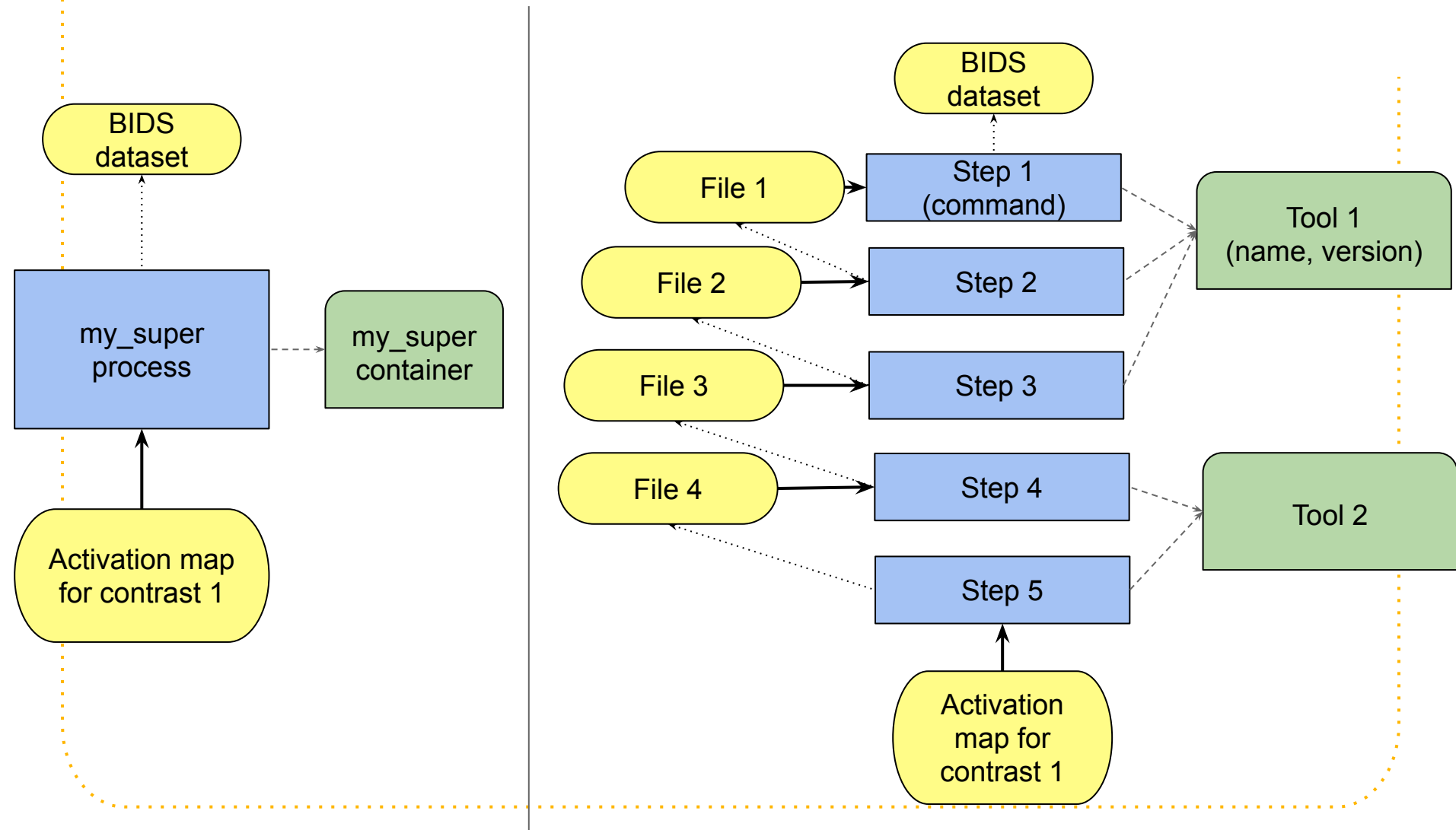
https://github.com/bids-standard/BEP028_BIDSprov/tree/master/examples/from_parsers

50+ examples in

- AFNI
- FSL
- SPM

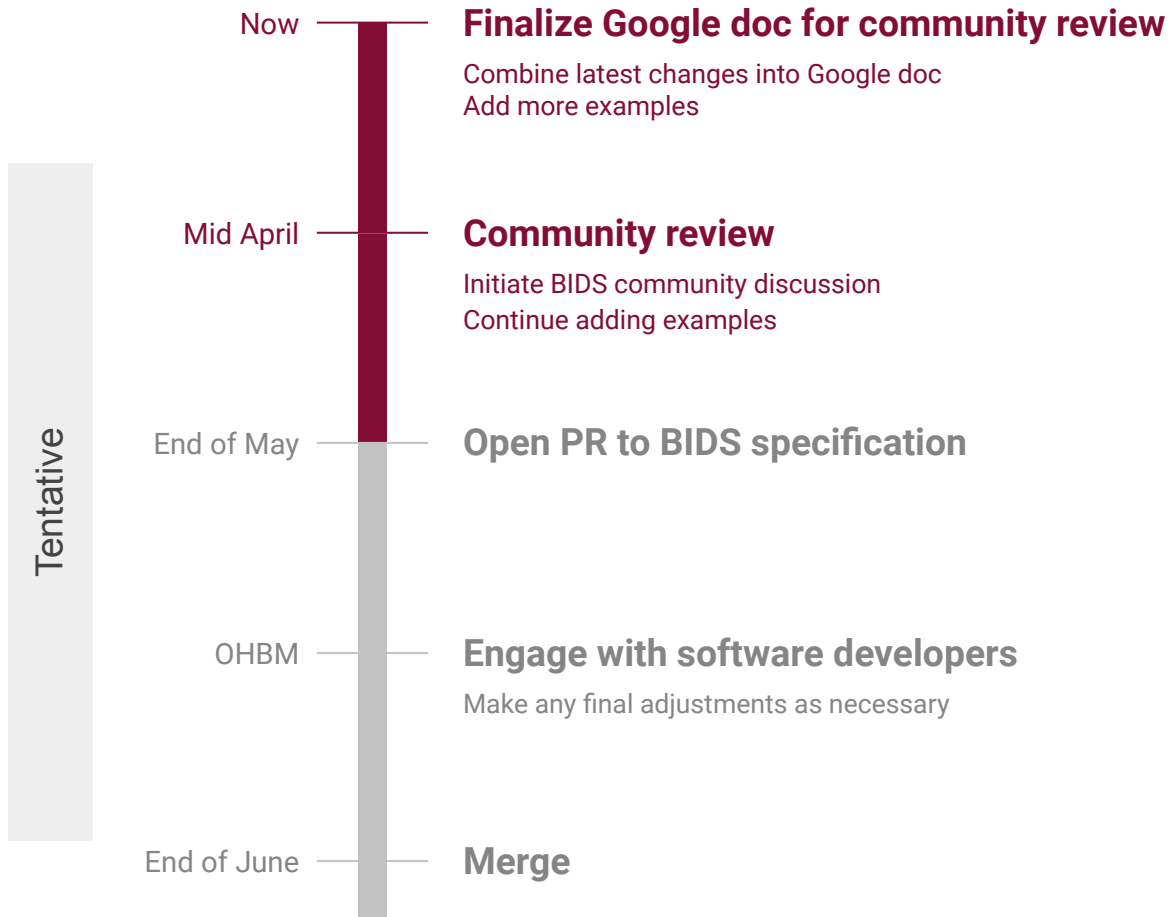


Different "levels" of provenance



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)

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