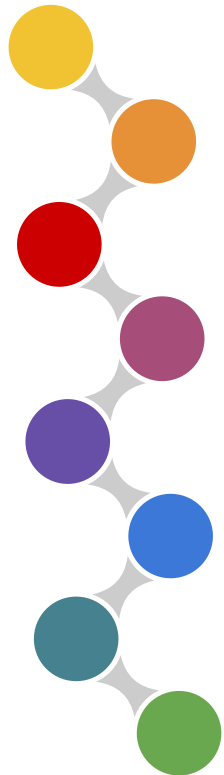


3ème Rencontres Sept 26-28, 2023

Ligne DevTech en Santé Numérique



Tracer la provenance des données de neuroimagerie : est-ce vraiment utile ?

Camille Maumet

Inria, Univ Rennes, Inserm, CNRS, IRISA



A crisis in **experimental research**

The **reproducibility crisis** has led to **reduced confidence in research findings**

Low reproduction rates in many fields :

Cancer research: <11%

Psychology: 36%

Medicine: 44%

(Begley & Ellis 2012 - Open Science Collab 2016 -Ioannidis 2005)

A crisis in **experimental research**

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(Begley & Ellis 2012 - Open Science Collab 2016 -Ioannidis 2005)

**Wasted money
& effort for
research**

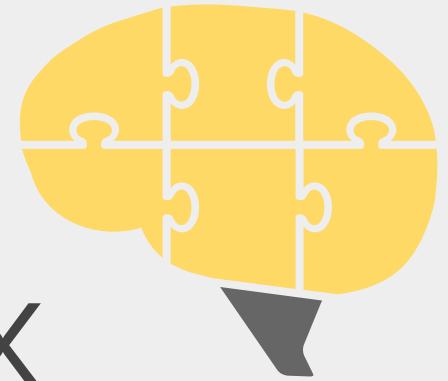
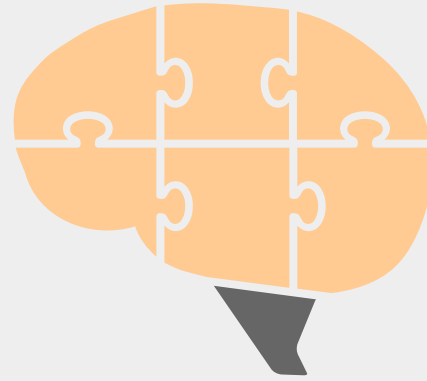


**Delayed
translation into
clinical practice**



**Reduced trust
in science**





On our way to fix
irreproducibility...

On our way **to fix irreproducibility**

Irreproducible with...

Same Data

On our way **to fix irreproducibility**

Irreproducible with...

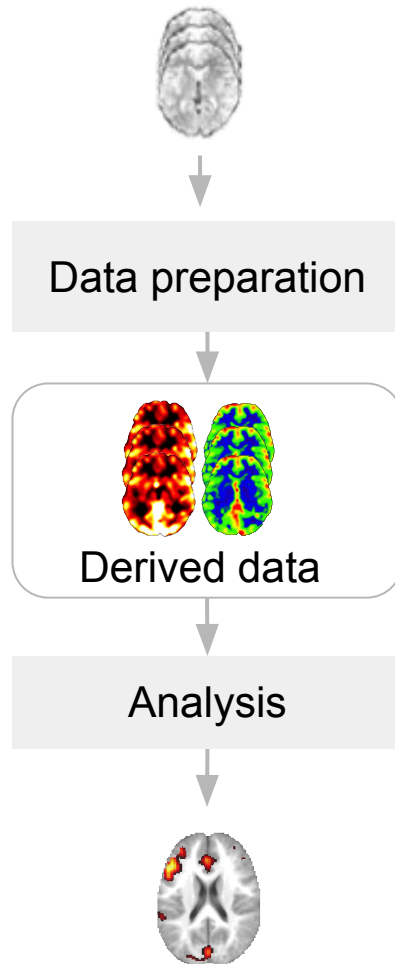
Same Data

Solutions: Sharing code,
containerization, guix, etc.

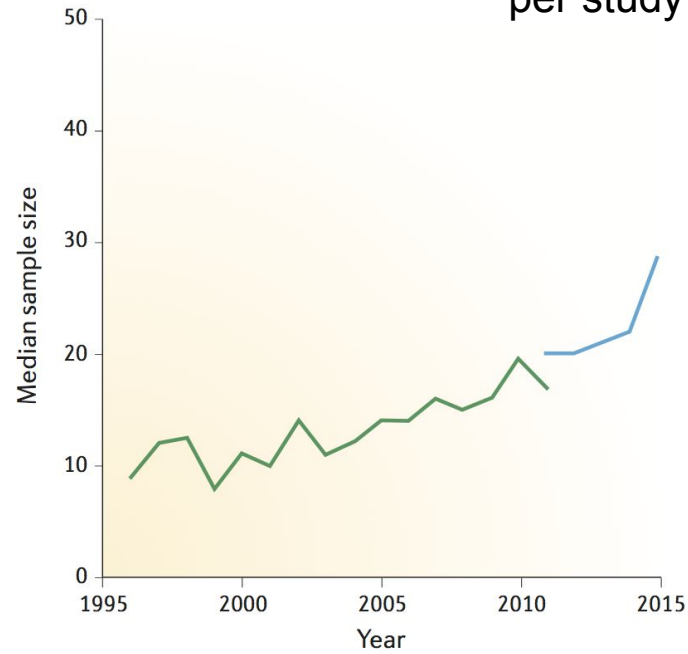
On our way **to fix irreproducibility**

Irreproducible with...

Different Data



about 30 participants
per study



[Poldrack et. al, Nature Neuroscience 2017]

1. False positive finding

Low statistical power

SCIENCE

A Waste of 1,000 Research Papers

Decades of early research on the genetics of depression were built on nonexistent foundations. How did that happen?

ED YONG MAY 17, 2019



SEAN NEL / SHUTTERSTOCK

In 1996, a group of European researchers found that a certain gene, called *SLC6A4*, might influence a person's risk of depression.

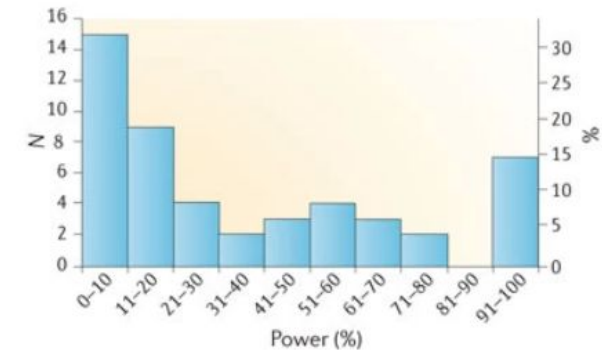
It was a blockbuster discovery at the time. The team found that a less active version of the gene was more common among 454 people who had mood disorders than in 570 who did not. In theory, anyone who had this particular gene variant could be at higher risk for depression, and that finding, they said, might help in diagnosing such disorders, assessing suicidal behavior, or even

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Power of neuroscience studies

Power = Prob. to correctly find a significant effect when a the alternative hypothesis is true.



[Button et. al, Nat Rev Neurosci 2013]

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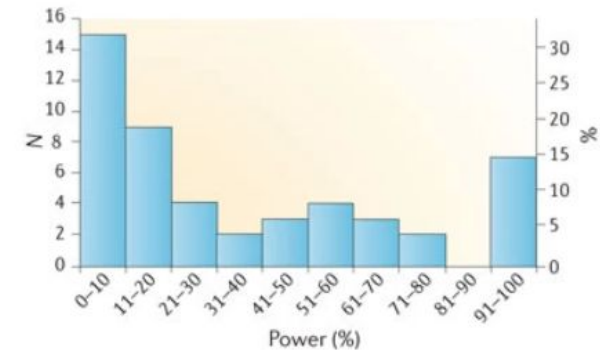
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Towards bigger datasets

SCIENCE

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2. Lack of generalizability and equitability

Lack of representativity and diversity

M PIXELS

CHRONIQUES
DES (R)ÉVOLUTIONS NUMÉRIQUES

VIE EN LIGNE

Une étude démontre les biais de la reconnaissance faciale, plus efficace sur les hommes blancs

Lorsqu'il s'agit de reconnaître le genre d'un homme blanc, des logiciels affichent un taux de réussite de 99 %. La tâche se complique lorsque la peau d'une personne est plus foncée, ou s'il s'agit d'une femme.

LE MONDE | 12.02.2018 à 14h52 • Mis à jour le 13.02.2018 à 18h18 |

Par Perrine Signoret

2. Lack of generalizability and equitability

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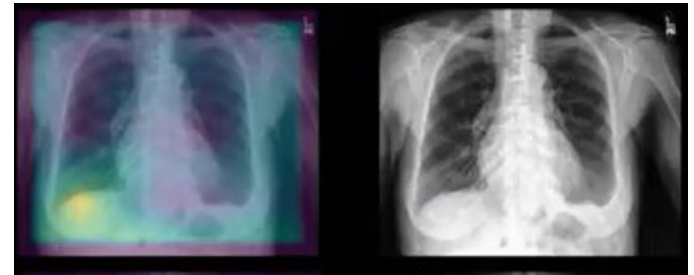
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LE MONDE | 12.02.2018 à 14h52 • Mis à jour le 13.02.2018 à 18h18 |

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X-ray: Lung opacity detection

Model trained on male images, tested on female images



[Larrazabal et. al, PNAS 2020]

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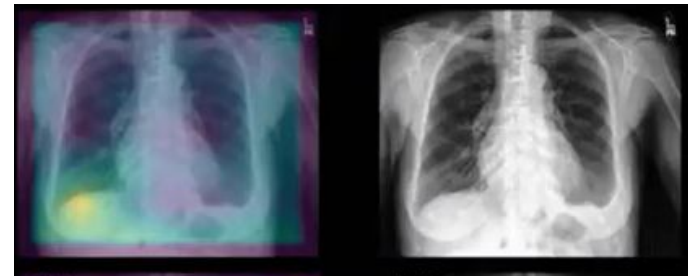
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[Larrazabal et. al, PNAS 2020]

We need representative
and diverse data
and teams



Open data

Unique study
30 participants



OpenNEURO

studyforrest.org



NEUROVAULT

L I E L N L F T Q K T Q R V
S M Y C O N N E C T O M E Q
G S P K K W A R R G K E H R

NITRC

OSF

- + Images
- + Homogenous
- Datasets



Open data

Unique study
30 participants



OpenNEURO

studyforrest.org

Consortium
1000 participants



ABIDE
Autism Brain Imaging
Data Exchange

1000 Functional
Connectomes Project

NEUROVAULT

L I E L N L F T Q K T Q R V
S M Y C O N N E C T O M E Q
G S P K K W A R R G K E H R



NITRC

OSF

CORR
CONSORTIUM FOR
RELIABILITY AND
REPRODUCIBILITY



- + Images
- + Homogenous
- Datasets

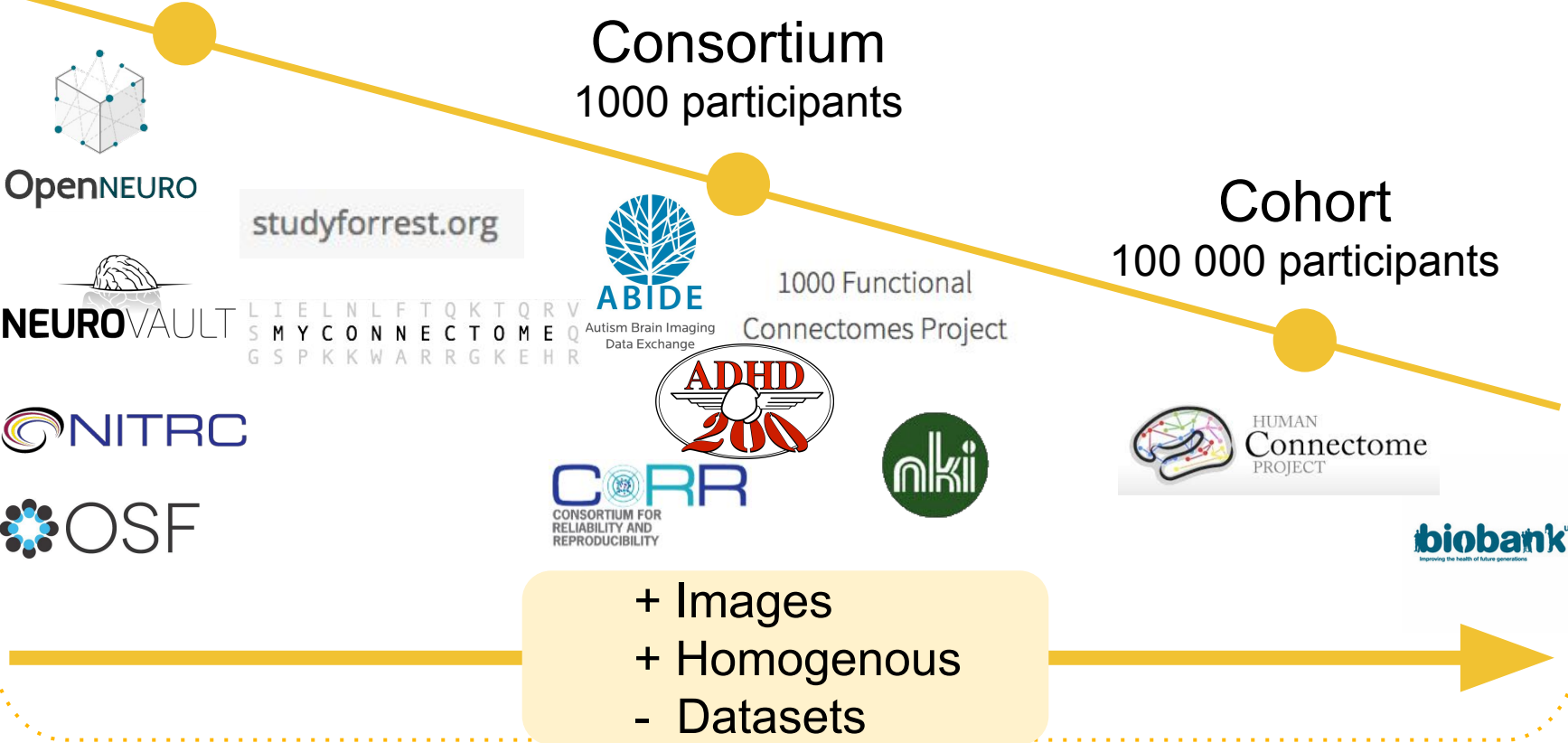


Open data

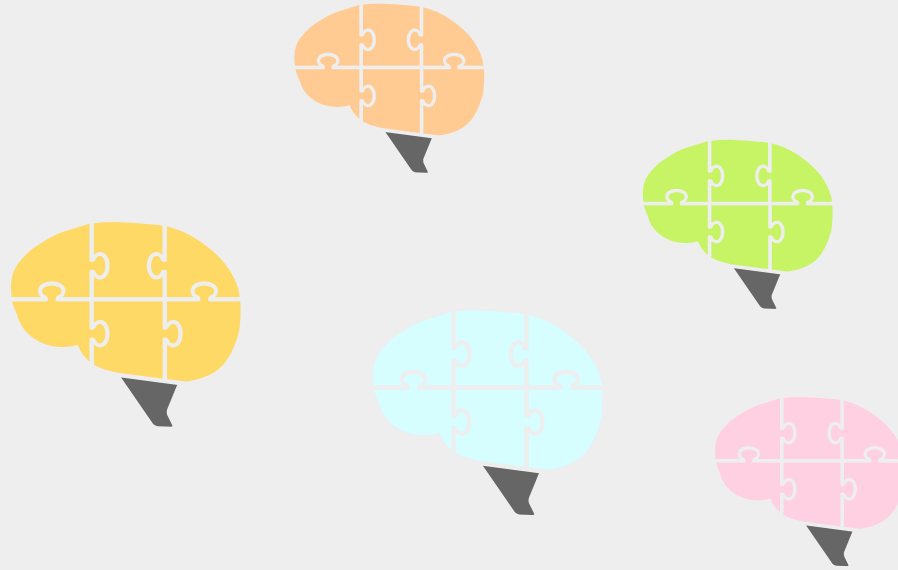
Unique study
30 participants

Consortium
1000 participants

Cohort
100 000 participants



Credits : Brains, Neil Conway, [Flickr](#) (CC BY 2.0)

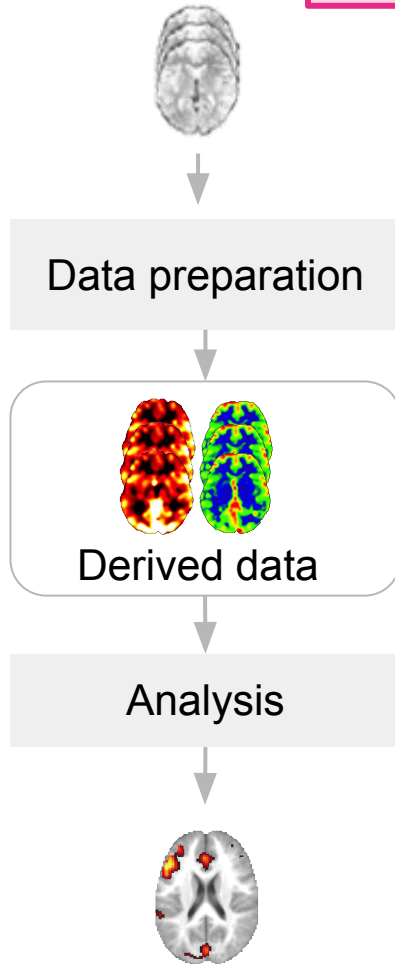


Different pipelines...
different results?

Towards **reproducible** neuroimaging

Irreproducible with...

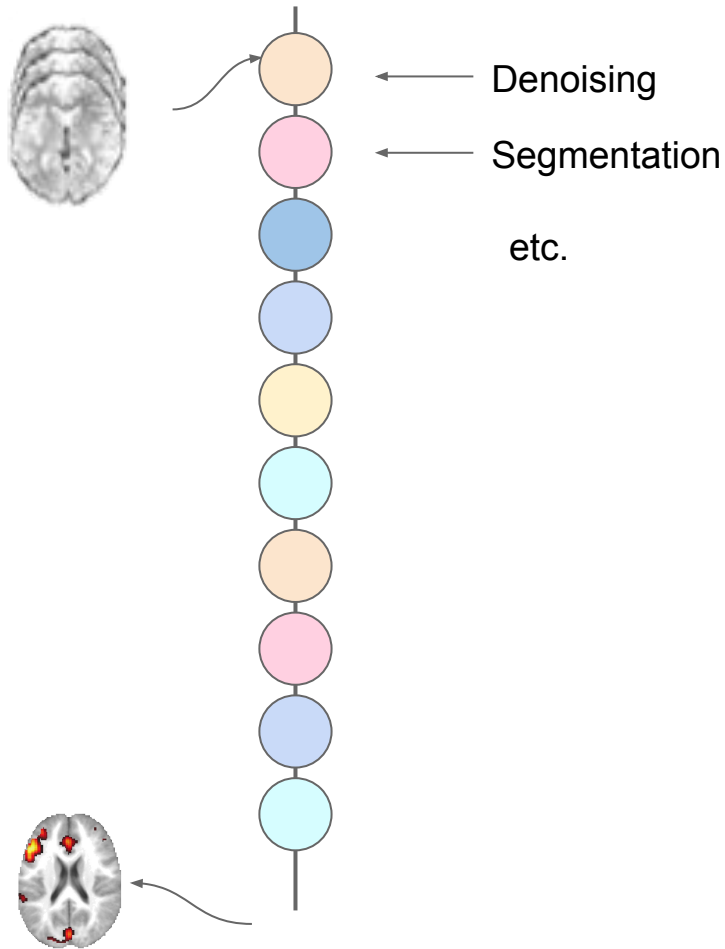
Different Post-processing Methods



Towards **reproducible** neuroimaging

Irreproducible with...

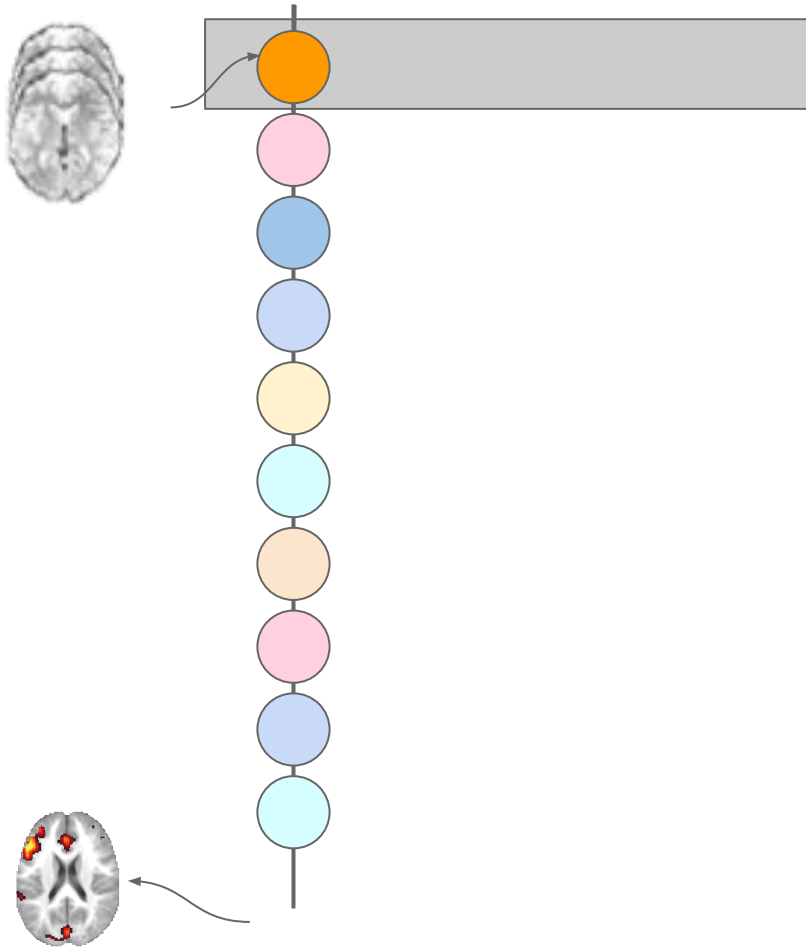
Different Post-processing Methods



Towards **reproducible** neuroimaging

Irreproducible with...

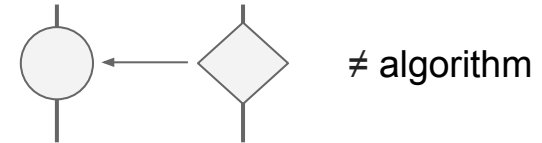
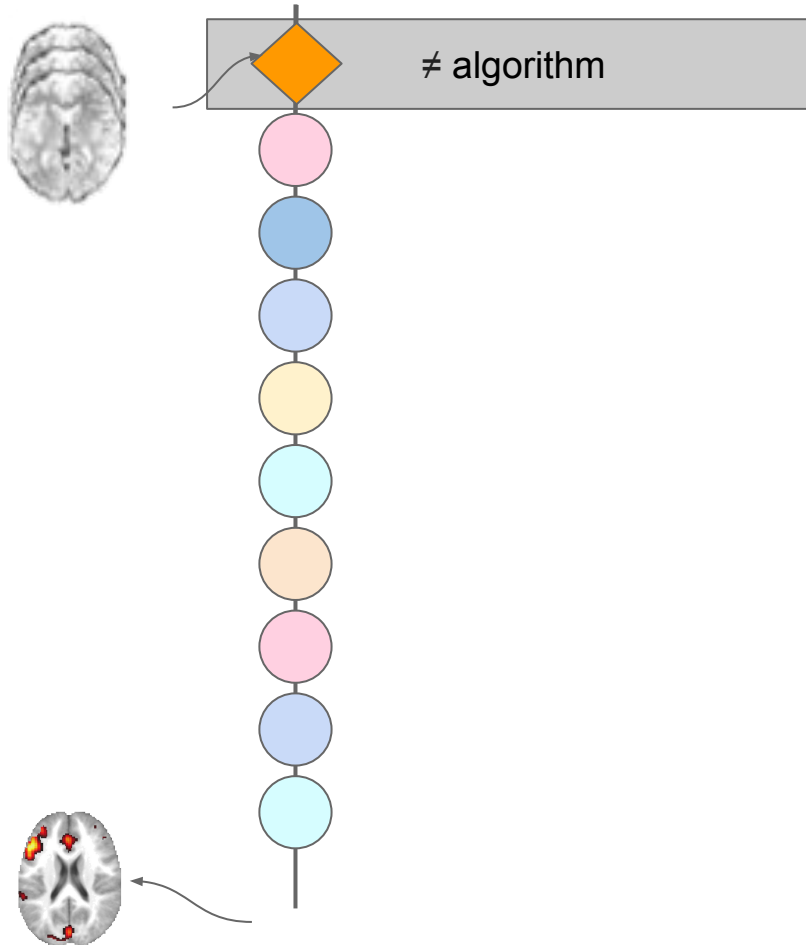
Different Post-processing Methods



Towards **reproducible** neuroimaging

Irreproducible with...

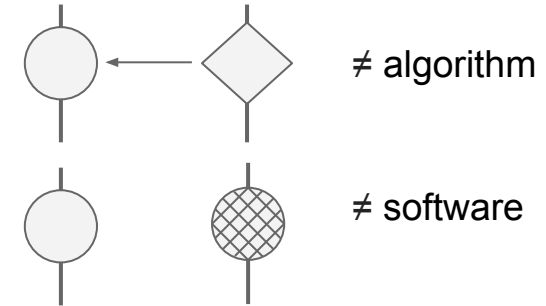
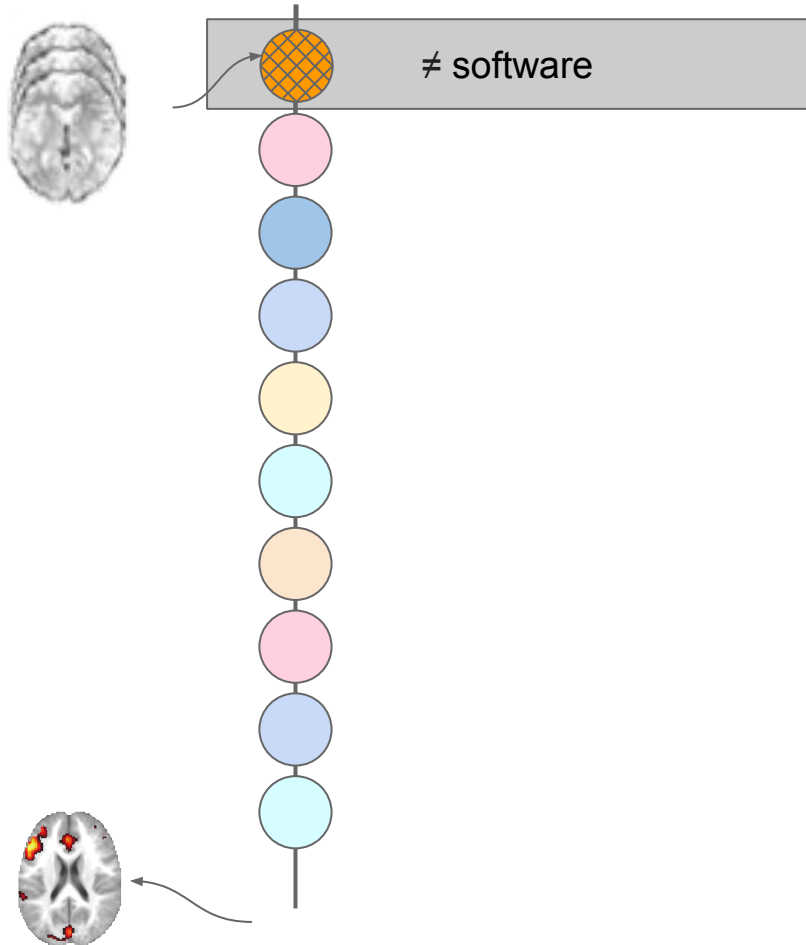
Different Post-processing Methods



Towards **reproducible** neuroimaging

Irreproducible with...

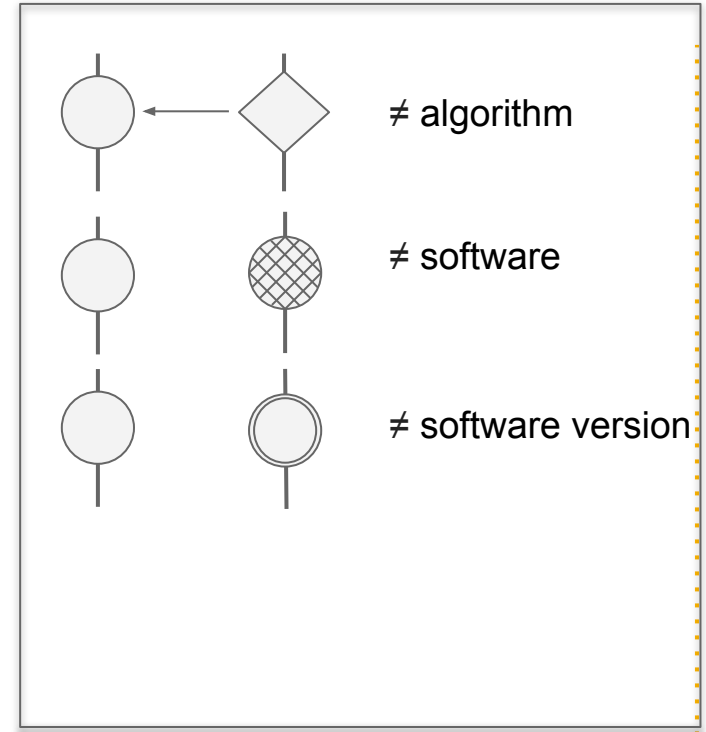
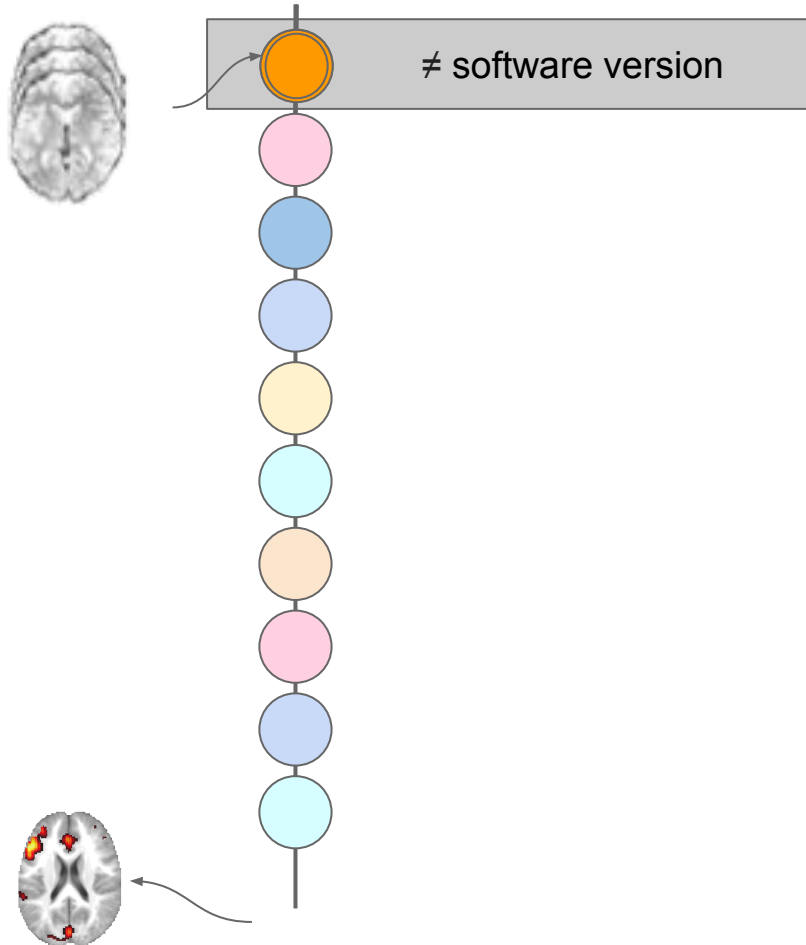
Different Post-processing Methods



Towards **reproducible** neuroimaging

Irreproducible with...

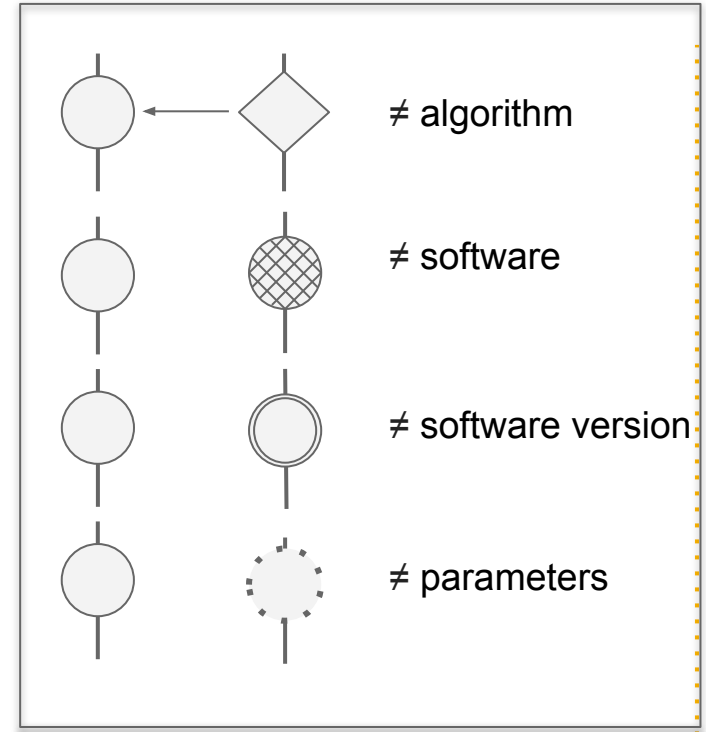
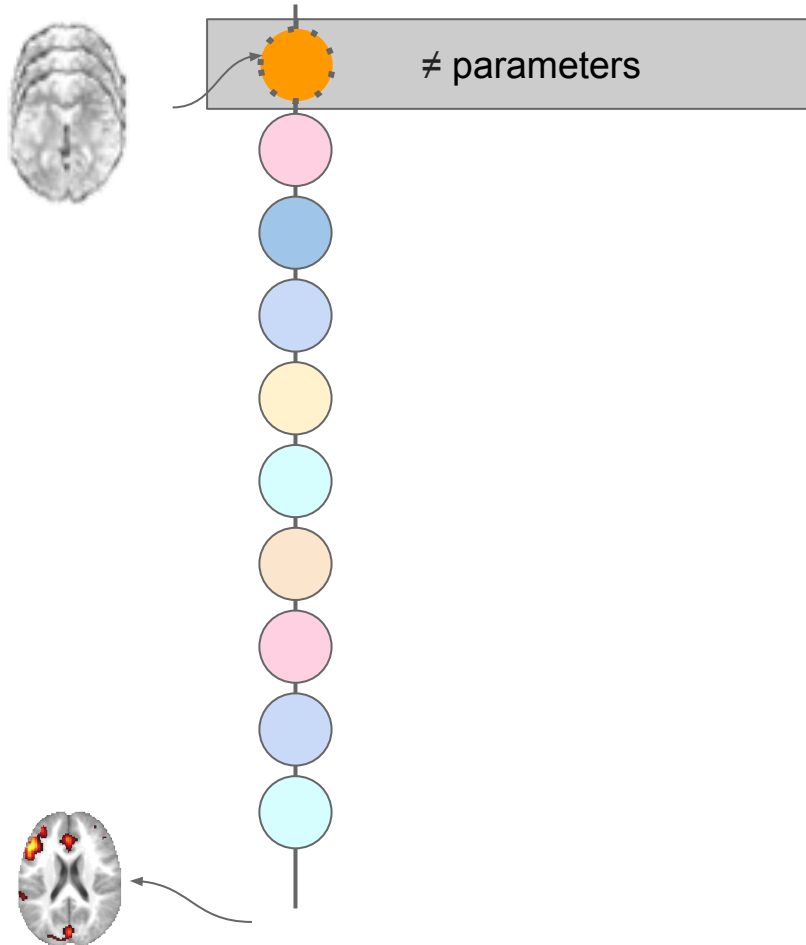
Different Post-processing Methods



Towards **reproducible** neuroimaging

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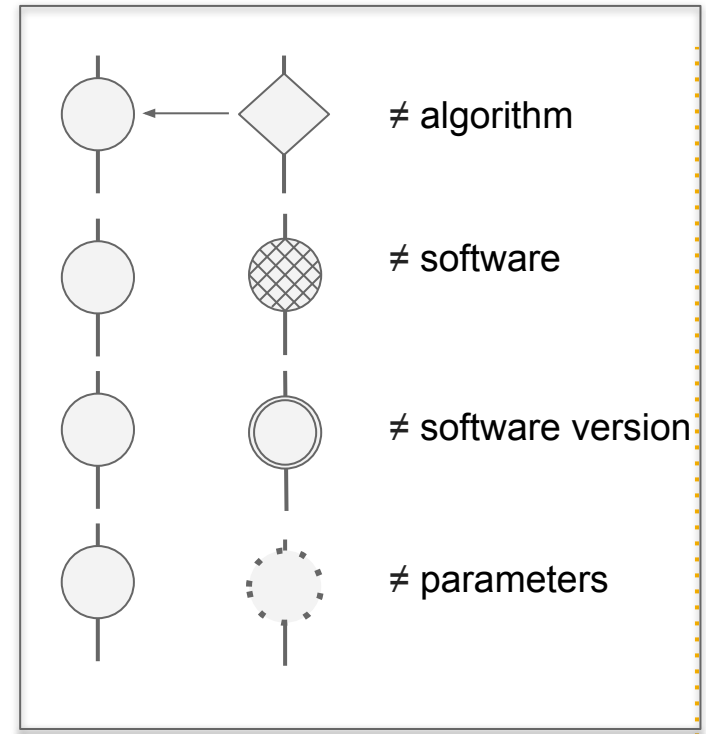
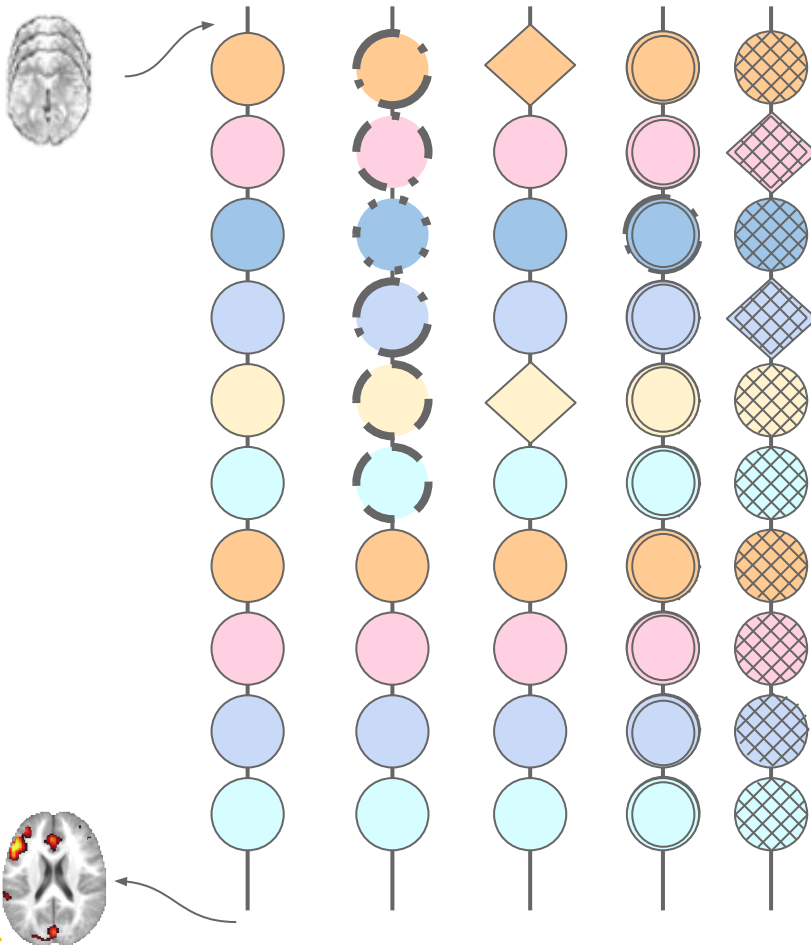
Different Post-processing Methods



Towards **reproducible** neuroimaging

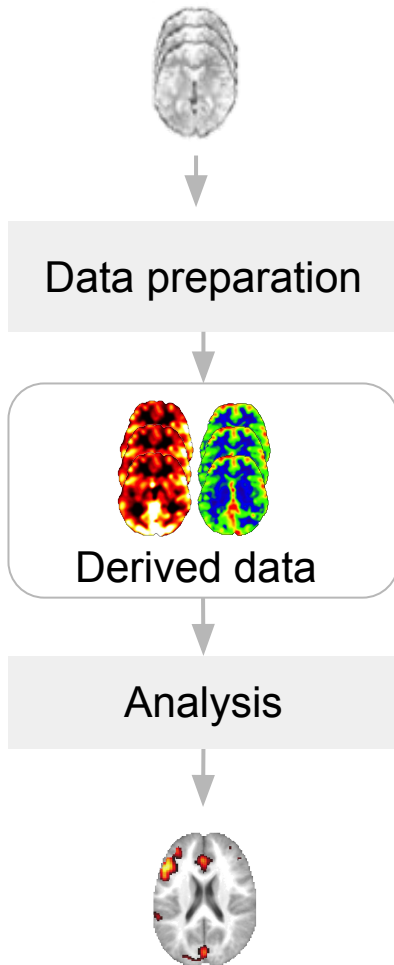
Irreproducible with...

Different Post-processing Methods

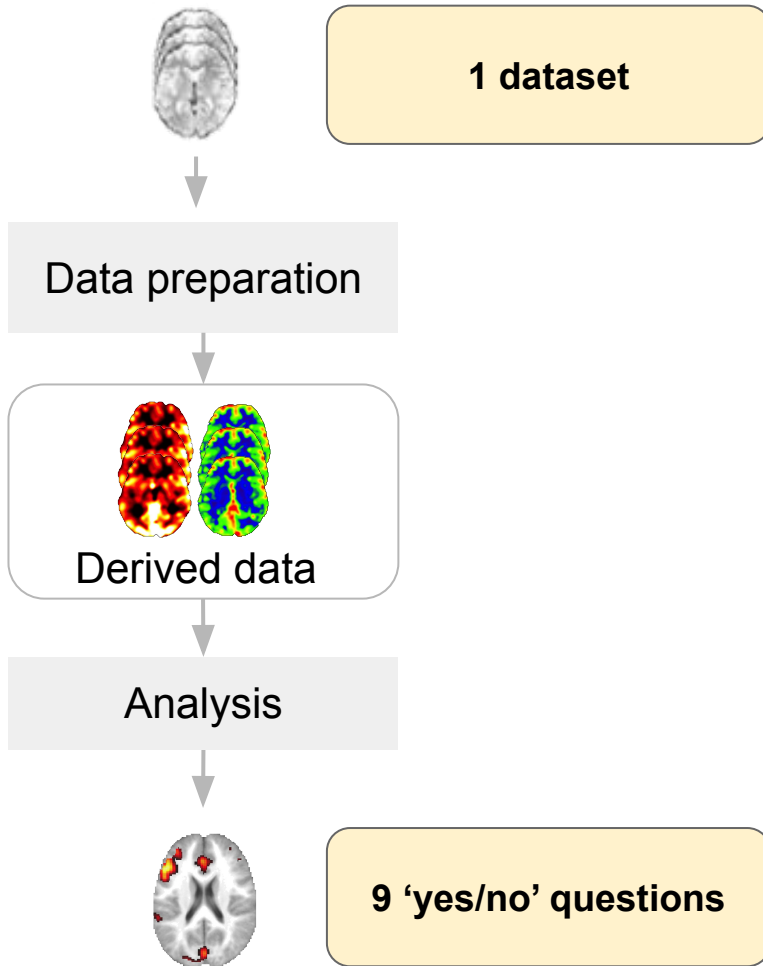


A family of acceptable pipelines
over 10^{30} combinations...

Many-analyst project : NARPS

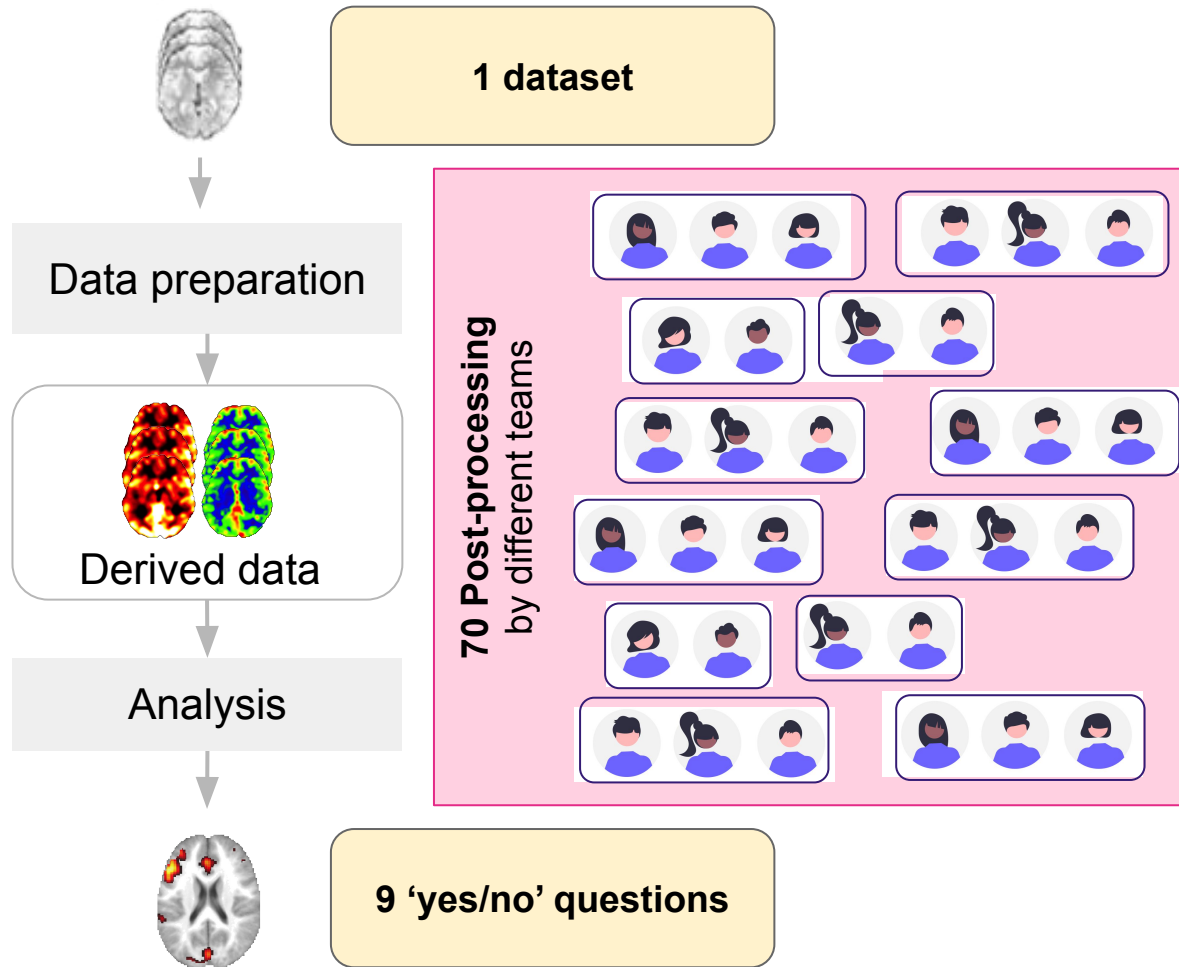


Many-analyst project : NARPS



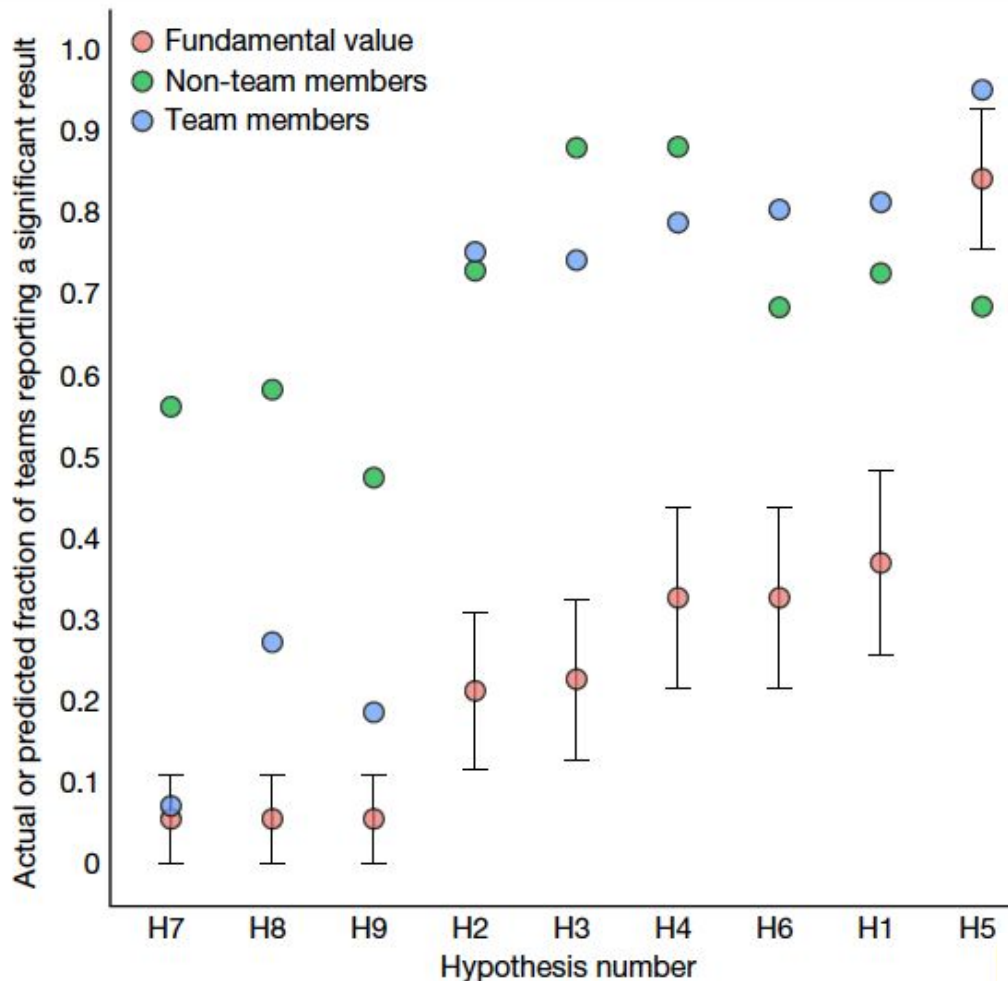
*e.g. Is there a parametric effect of gain:
Positive effect in ventromedial PFC -
for the equal indifference group?*

Many-analyst project : NARPS



Many-analyst project : NARPS

Results over the **70 post-processing pipelines**:

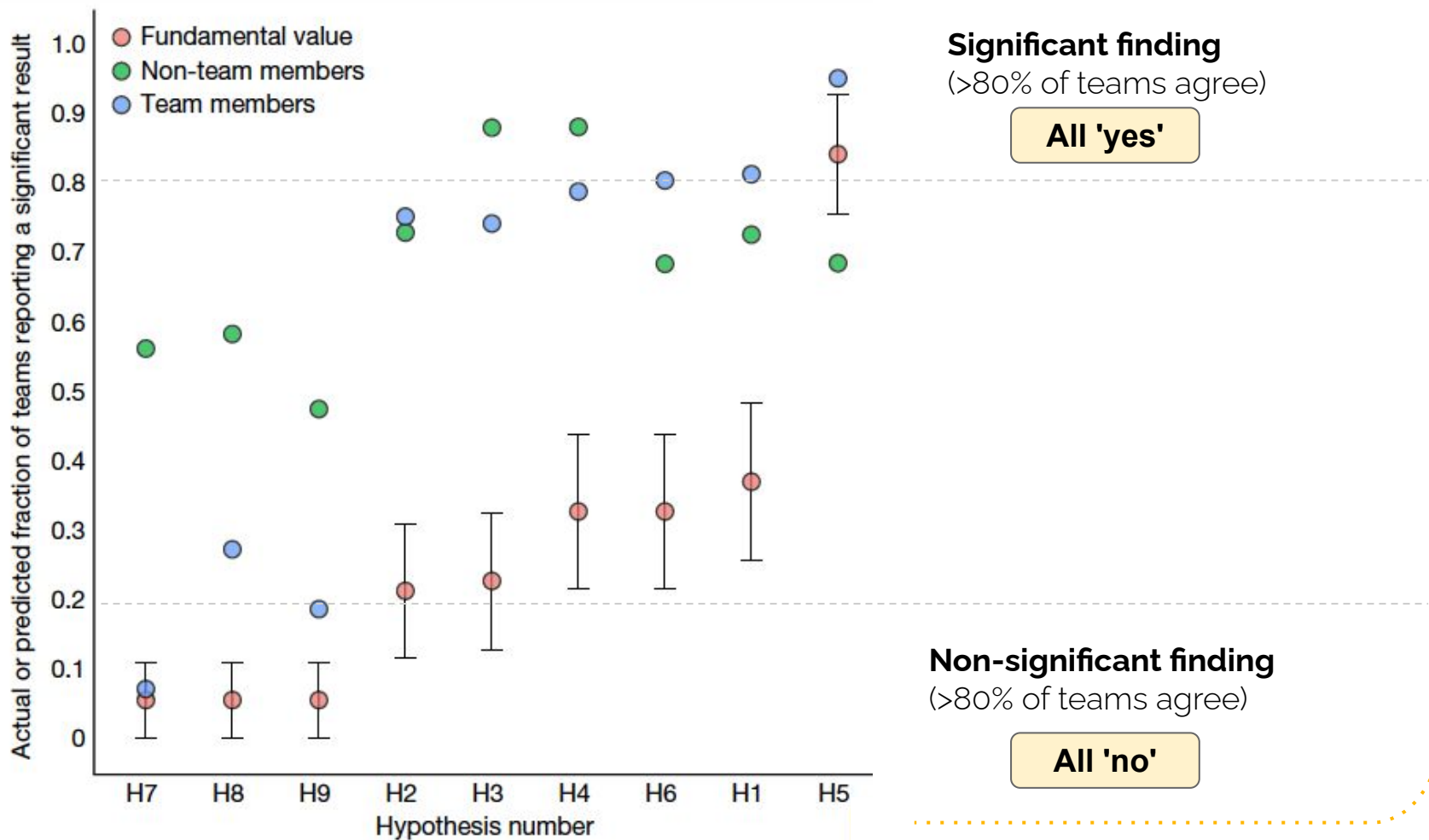


9 'yes/no' questions

[Botvinik-Nezer et. al, Nature 2020]

Many-analyst project : NARPS

Results over the **70 post-processing pipelines**:

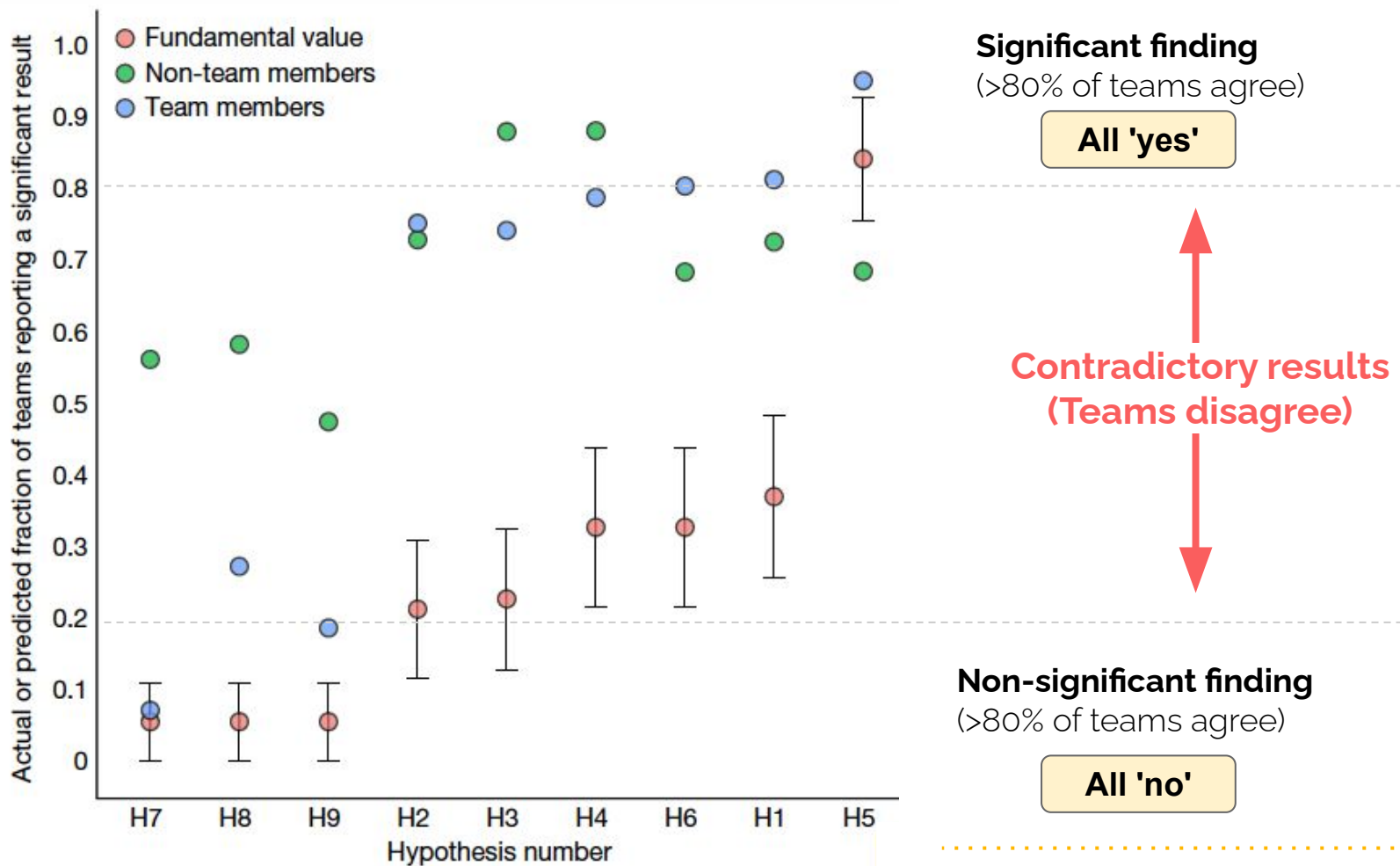


9 'yes/no' questions

[Botvinik-Nezer et. al, Nature 2020]

Many-analyst project : NARPS

Results over the **70 post-processing pipelines**:



9 'yes/no' questions

[Botvinik-Nezer et. al, Nature 2020]

Different levels of variability in post-processing pipelines

- Different end-to-end pipelines [Carp 2013]
- Different Software Version [Gronenschild 2012]
- Different operating system [Glatard 2015]

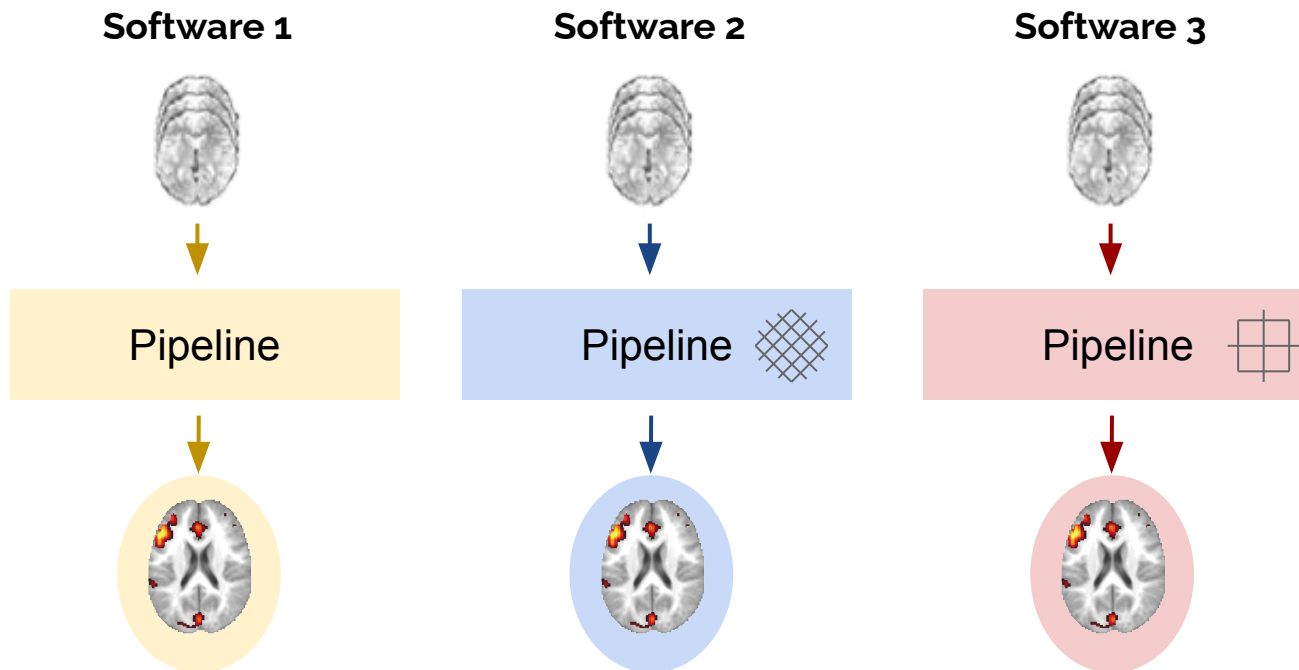
- Different **post-processing software packages** [Bowring 2019, 2021]

Variability across software

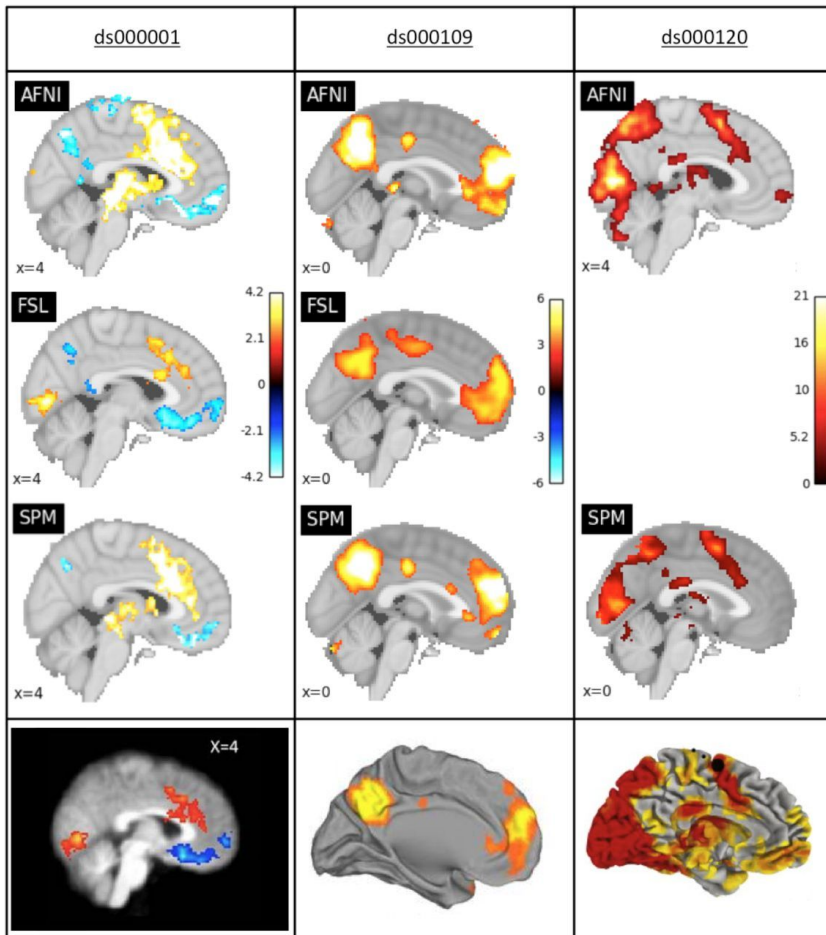
- Reproduced 3 published functional MRI studies
- Using 3 different software



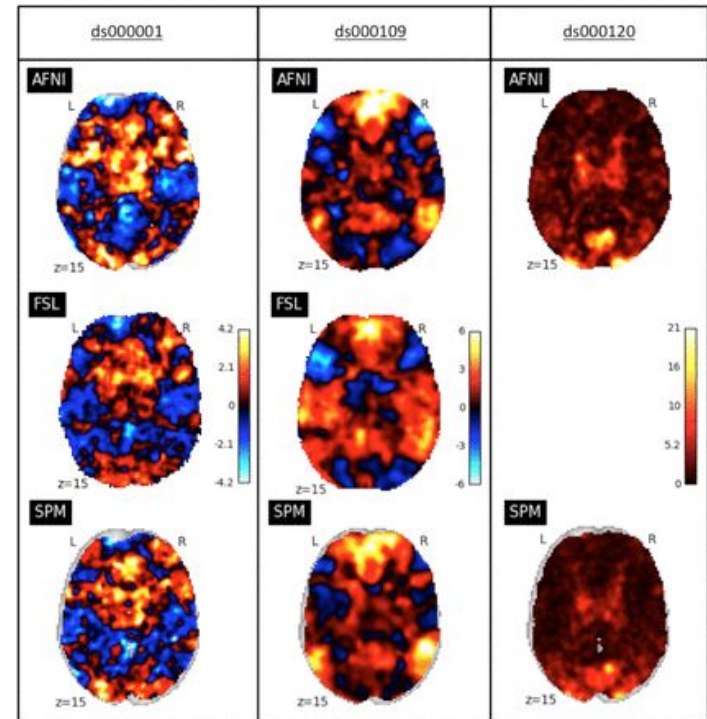
Alex Bowring Tom Nichols



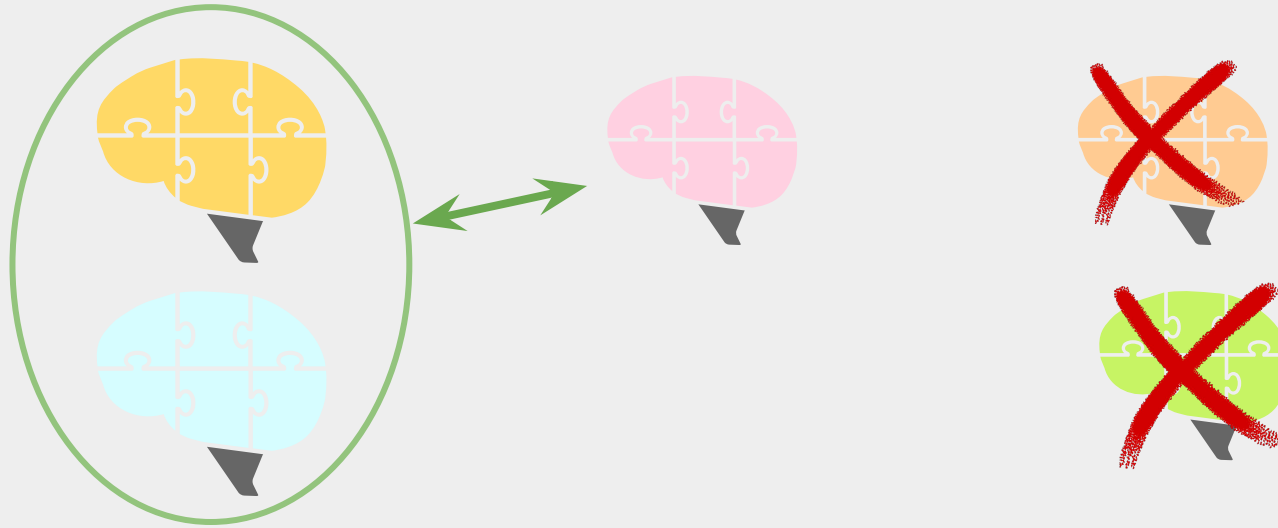
Software Comparison Project



Comparison of the final results



Comparison of the statistic maps



Understanding
analytical variability

Explaining analytical variability...

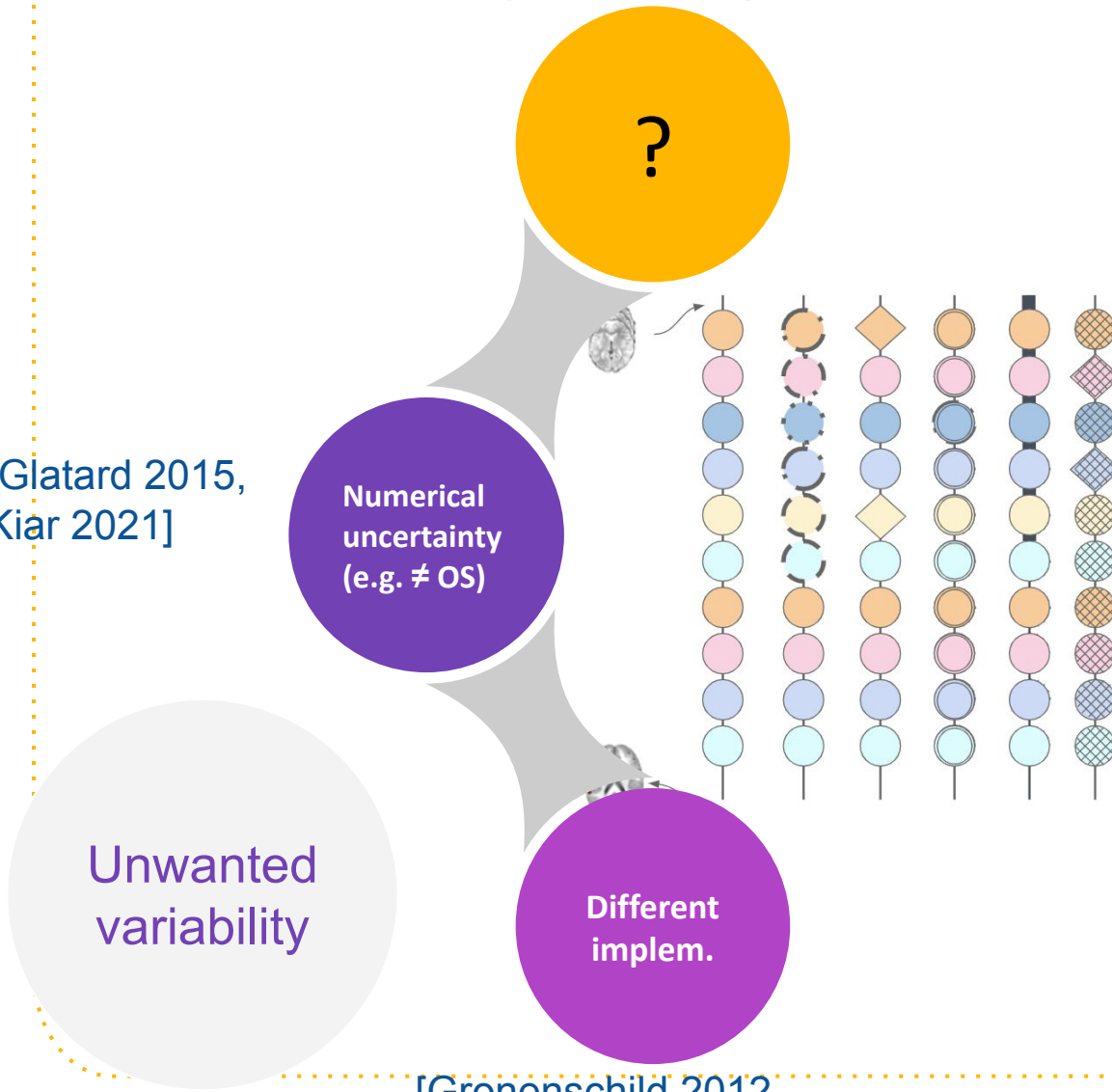
[Glatard 2015,
Kiar 2021]

Numerical
uncertainty
(e.g. \neq OS)

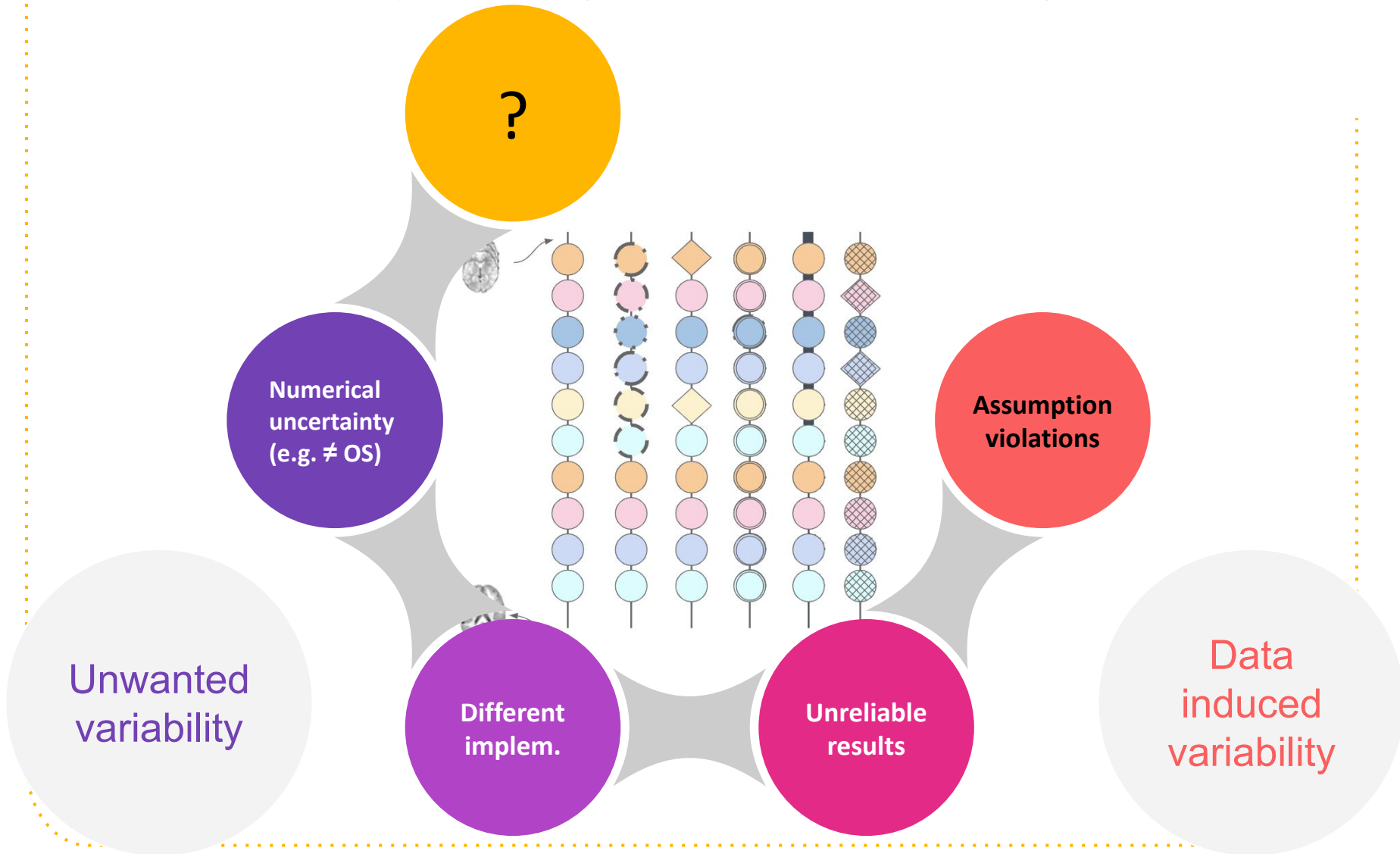
Unwanted
variability

Different
implem.

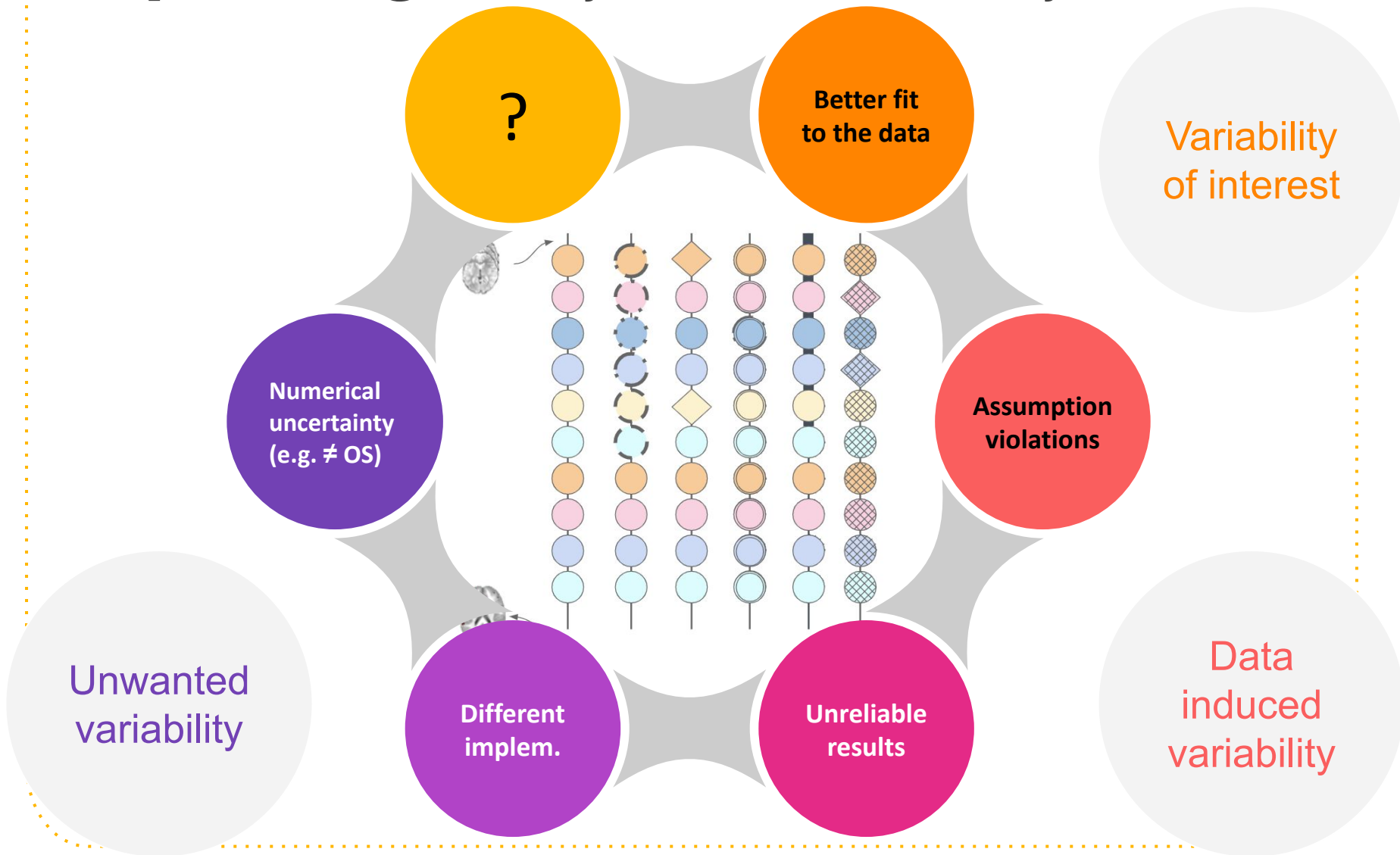
[Gronenschild 2012,
Bowring 2019]



Explaining analytical variability...



Explaining analytical variability...





Boris Clenet

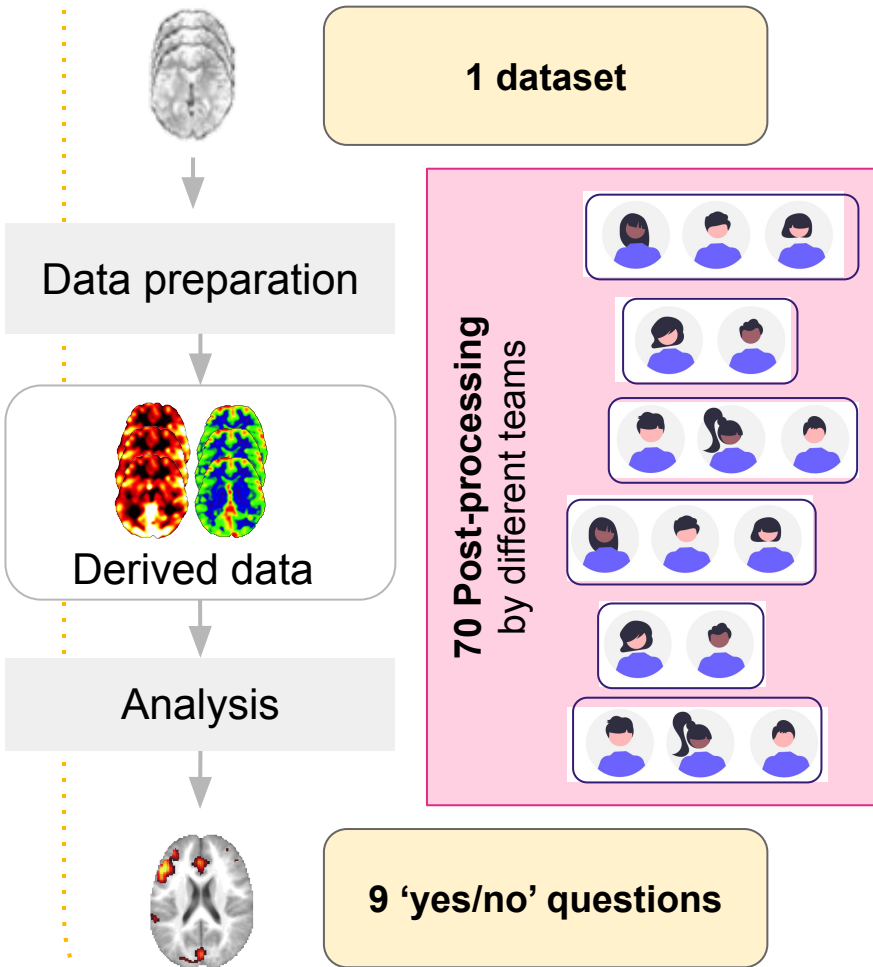


Elodie Germani



JérémY Lefort-Besnard

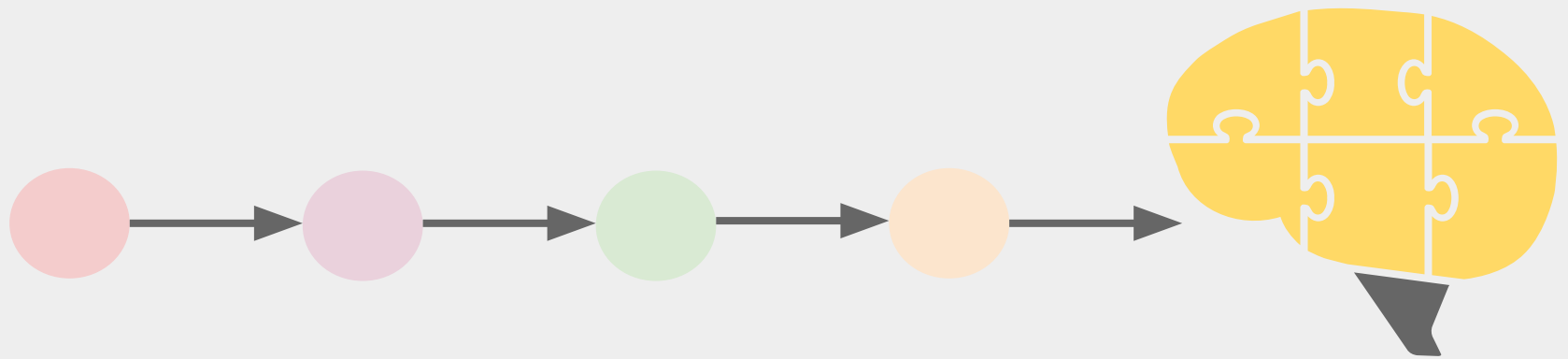
NARPS open pipelines



- (Re)-coding the 70 pipelines
- Collaborative effort



https://github.com/Inria-Empenn/narps_open_pipelines/



Recording brain
imaging **provenance**

The BIDS-Prov Team

BIDS Extension Proposal 28



Satra
Ghosh

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.

Brain Imaging Data Structure



<https://bids.neuroimaging.io>

SCIENTIFIC DATA 

OPEN

SUBJECT CATEGORIES

- » Data publication and archiving
- » Research data

The brain imaging data structure, a format for organizing and describing outputs of neuroimaging experiments

Krzysztof J. Gorgolewski¹, Tibor Auer², Vince D. Calhoun^{3,4}, R. Cameron Craddock^{5,6}, Samir Das⁷, Eugene P. Duff⁸, Guillaume Flandin⁹, Satrajit S. Ghosh^{10,11}, Tristan Glatard^{7,12}, Yaroslav O. Halchenko¹³, Daniel A. Handwerker^{1,4}, Michael Hanke^{15,16}, David Keator¹⁷, Xiangrui Li¹⁸, Zachary Michael¹⁹, Camille Maumet²⁰, B. Nolan Nichols^{21,22}, Thomas E. Nichols^{20,23}, John Pellman⁵, Jean-Baptiste Poline²⁴, Ariel Rokem²⁵, Gunnar Schaefer^{1,26}, Vanessa Sochat²⁷, William Triplett¹, Jessica A. Turner^{3,28}, Gaël Varoquaux²⁹ & Russell A. Poldrack¹

Received: 18 December 2015

Accepted: 19 May 2016

Published: 21 June 2016

A brief history of BIDS

2015

Spring: Kickoff meeting at Stanford Uni.
Community reach out

2016

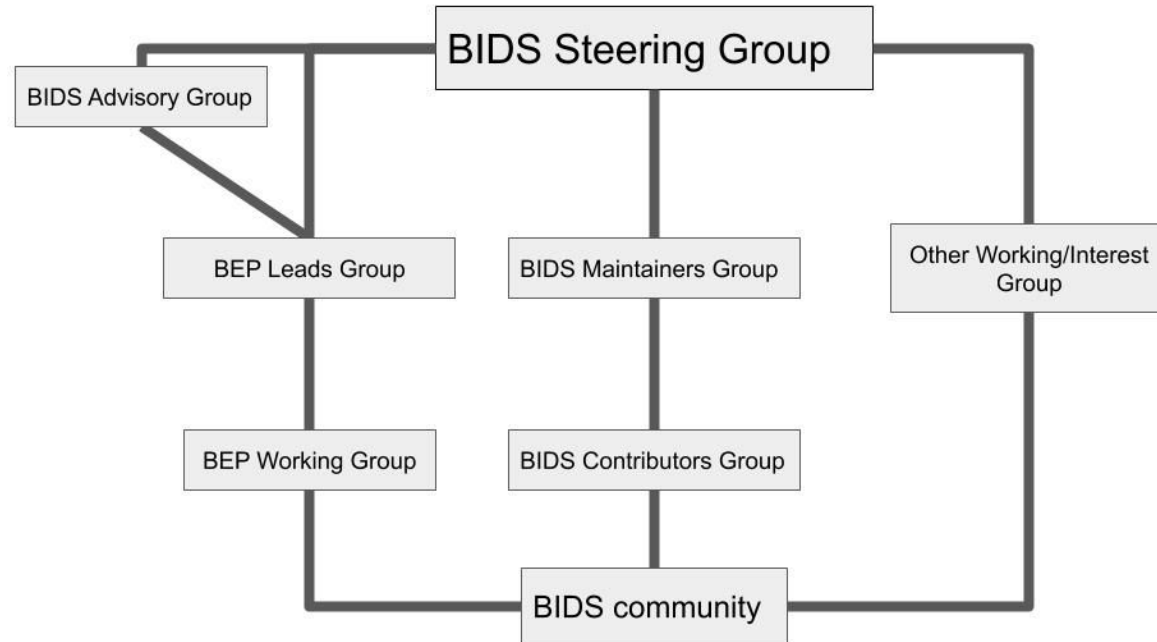
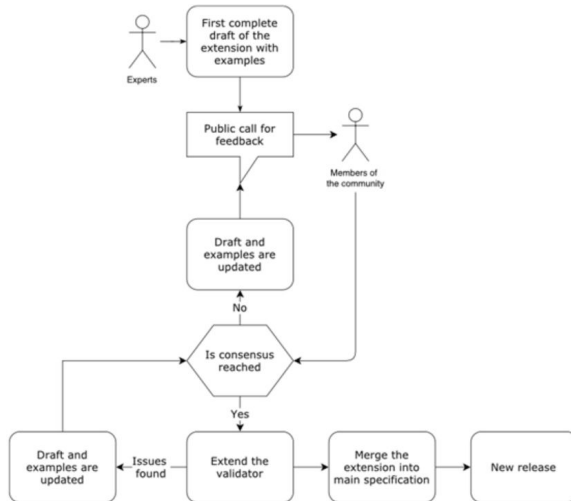
Paper published & release 1.0.0

BIDS extension proposals

MEG, EEG and iEEG (2019), PET (2021)
Genetic (2020), Microscopy (2022),
fNIRS (open for community feedback)

BIDS governance

BIDS Extension Proposals



Guiomar Niso



Melanie Ganz



Robert Oostenveld



Russ Poldrack



Kirstie Whitaker

BIDS Steering committee

What is BIDS? A community!



Technical challenges: Standards, Databases, Good practices (version control, etc.)

A culture change: towards community-driven research

- Making resources **available to the scientific community**
- **Reusing** existing resources (datasets, tools) that were created by others
- **Developing tools collaboratively** with a community of contributors

<https://github.com/bids-standard>

BIDS in 2023



Chris Gorgolewski
@chrisgorgo



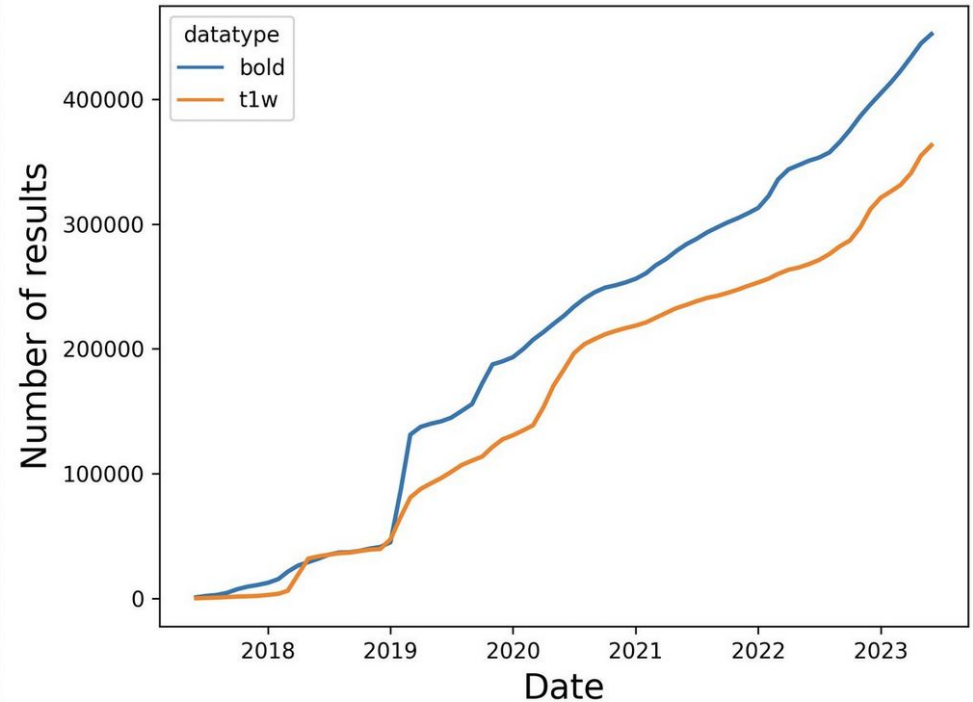
Almost 1 million brain scans in BIDS and using MRIQC! @oesteban

[Traduire le post](#)



Russ Poldrack @russpoldrack · 13 juin

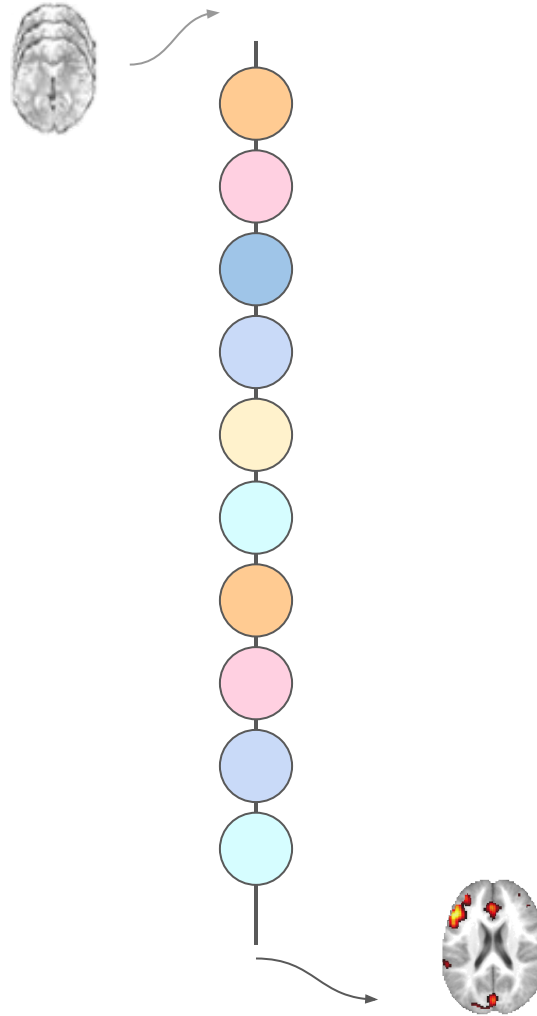
Just did an updated analysis of the MRIQC Web API database to get a lower bound on how many unique BIDS datasets exist out in the wild. The growth is pretty astonishing... (these are counts of unique T1w and BOLD images that have been processed using MRIQC)



9:28 PM · 13 juin 2023 · 9 382 vues

<https://nitter.net/chrisgorgo/status/1668701996000370689>

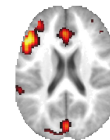
What is **BIDS-Prov**?



What is **BIDS-Prov**?

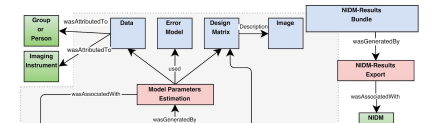
```
my_dataset/  
├── participants.tsv  
├── sub-01/  
│   ├── anat/  
│   │   └── sub-01_T1w.nii.gz  
│   └── func/
```

BIDS
“raw”

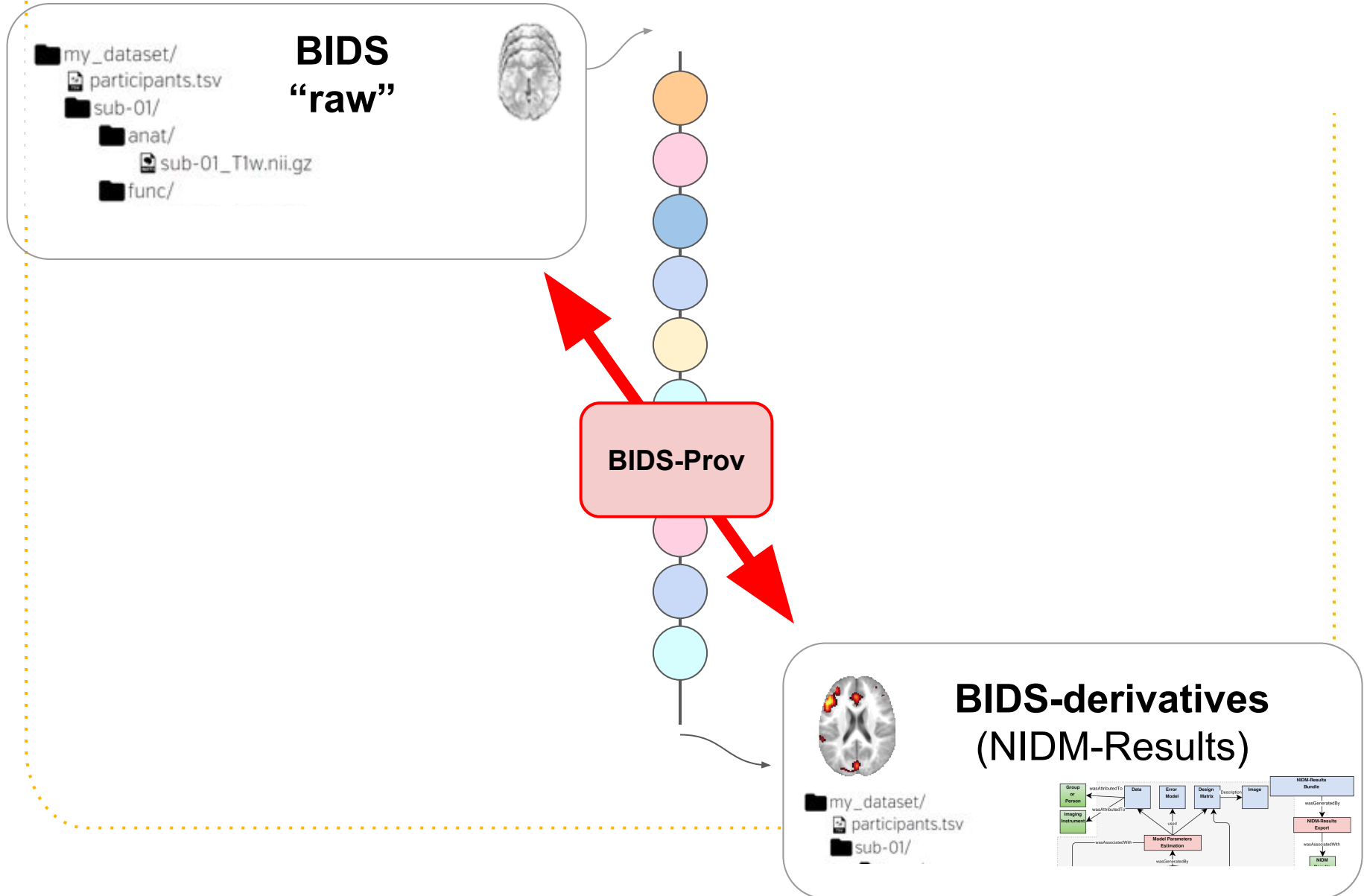


BIDS-derivatives
(NIDM-Results)

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



What is **BIDS-Prov**?



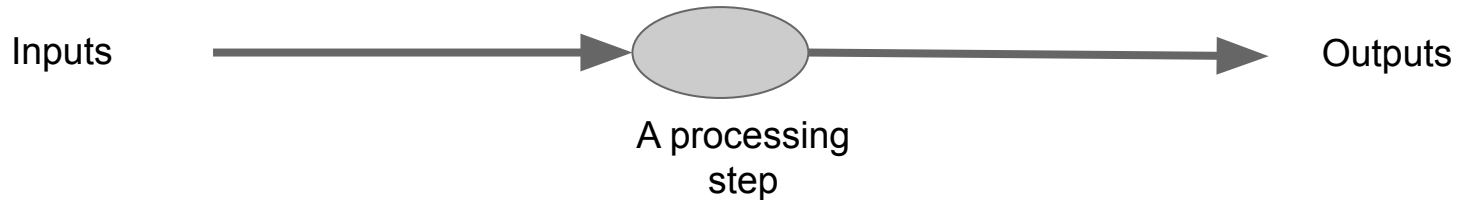
Goal of BIDS-Prov

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

BIDS-Prov extension proposal

Key idea:

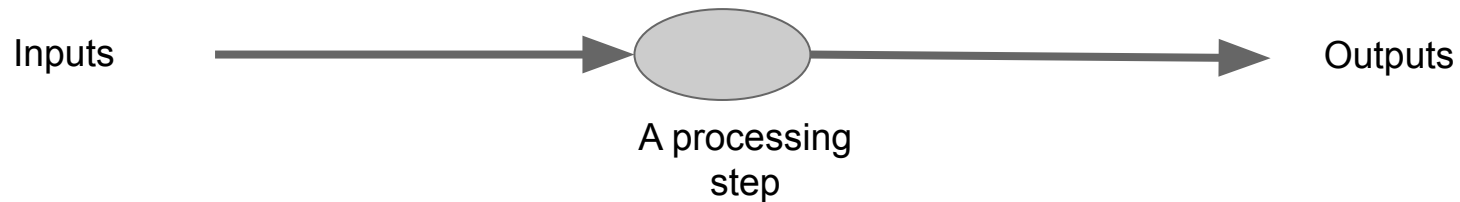
A common model to represent **chaining of processing** (for now no description of the 'meaning' of those processing)



BIDS-Prov extension proposal

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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:

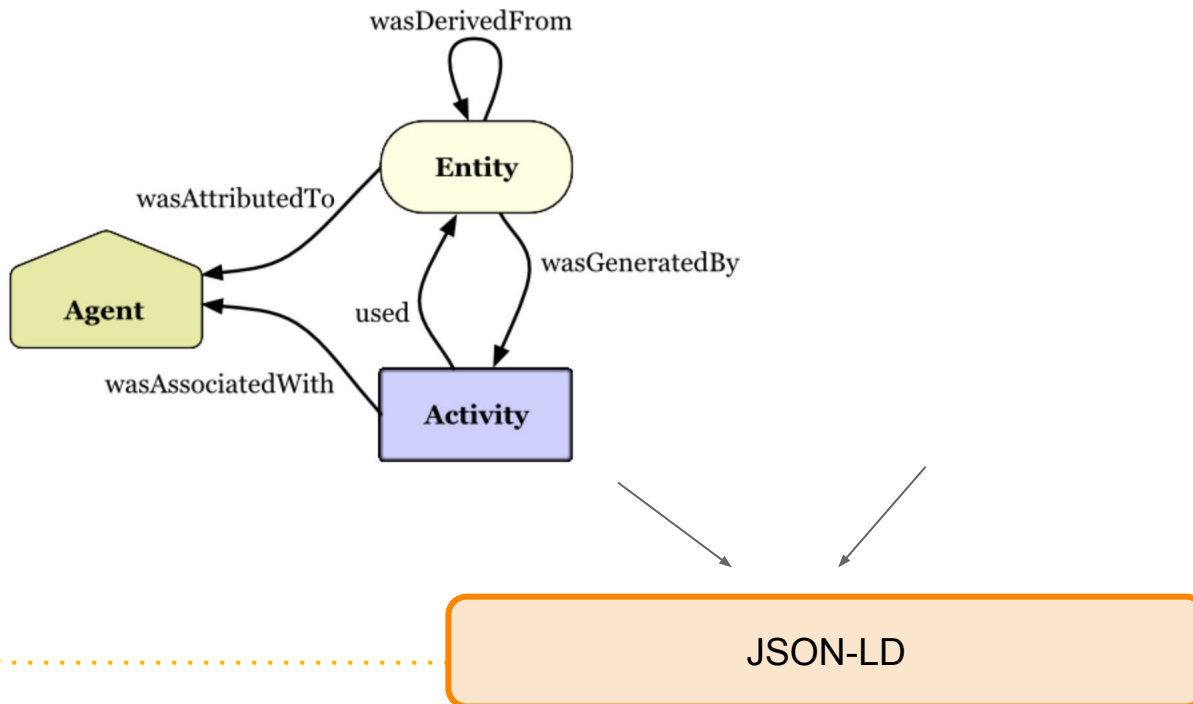
- File-level provenance `<path-to-file><file-name-with-ext>.prov.jsonld`
- Dataset-level provenance `prov/[<subfolders>*/]<label>.prov.jsonld`

BIDS-Prov extension proposal

RDF

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

BIDS



Example

```
{ "@context": "https://purl.org/nidash/bidsprov/context.json",
  "BIDSProvVersion": "0.0.1",
  "Records": {
    "Software": [
      { "Id": "urn:spm-030f431e-c8bd",
        "label": "SPM",
        "version": "SPM12r7224"}
    ],
    "Activities": [
      { "Id": "urn:segment-d124a1ec-ede9",
        "Label": "Segment",
        "Used": [
          "bids::sub-001/anat_sub-01_T1w.nii"
        ],
        "AssociatedWith": "urn:spm-030f431e-c8bd",
        "Command": "matlabbatch{7}.spm.spatial.preproc.channel.vols(1) = [...] }
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      { "Id": "bids::sub-001/anat_sub-01_T1w.nii",
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Example

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Software used

Example

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Software used

SPM

Example

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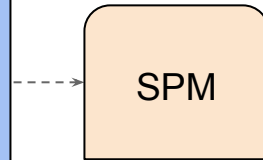
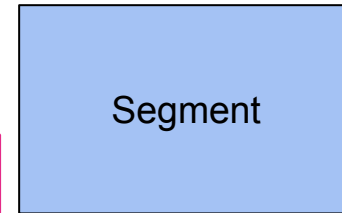
Processing
applied
("steps")

SPM

Example

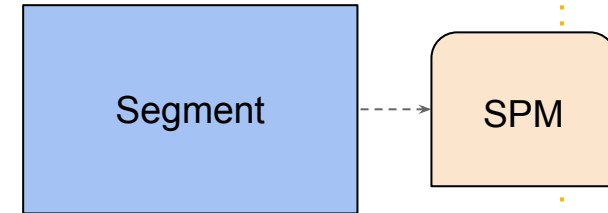
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{ "@context": "https://purl.org/nidash/bidsprov/context.json",  
  "BIDSProvVersion": "0.0.1",  
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    "Software": [  
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Example

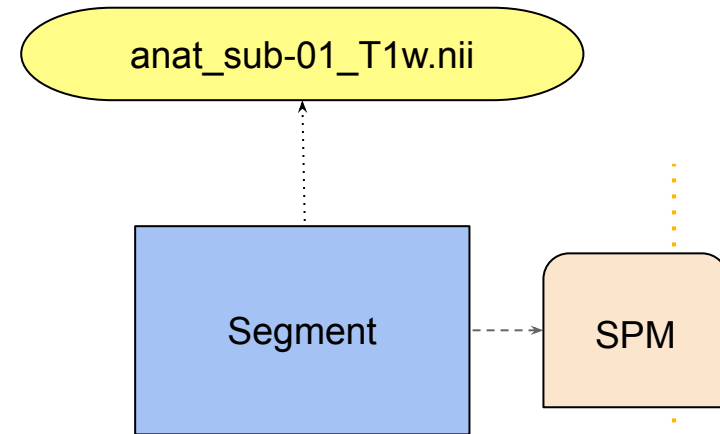
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Inputs and
outputs (files)

Example

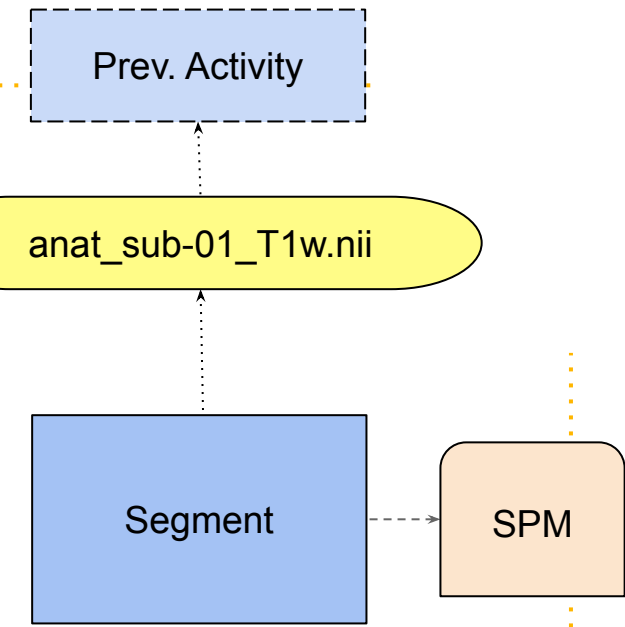
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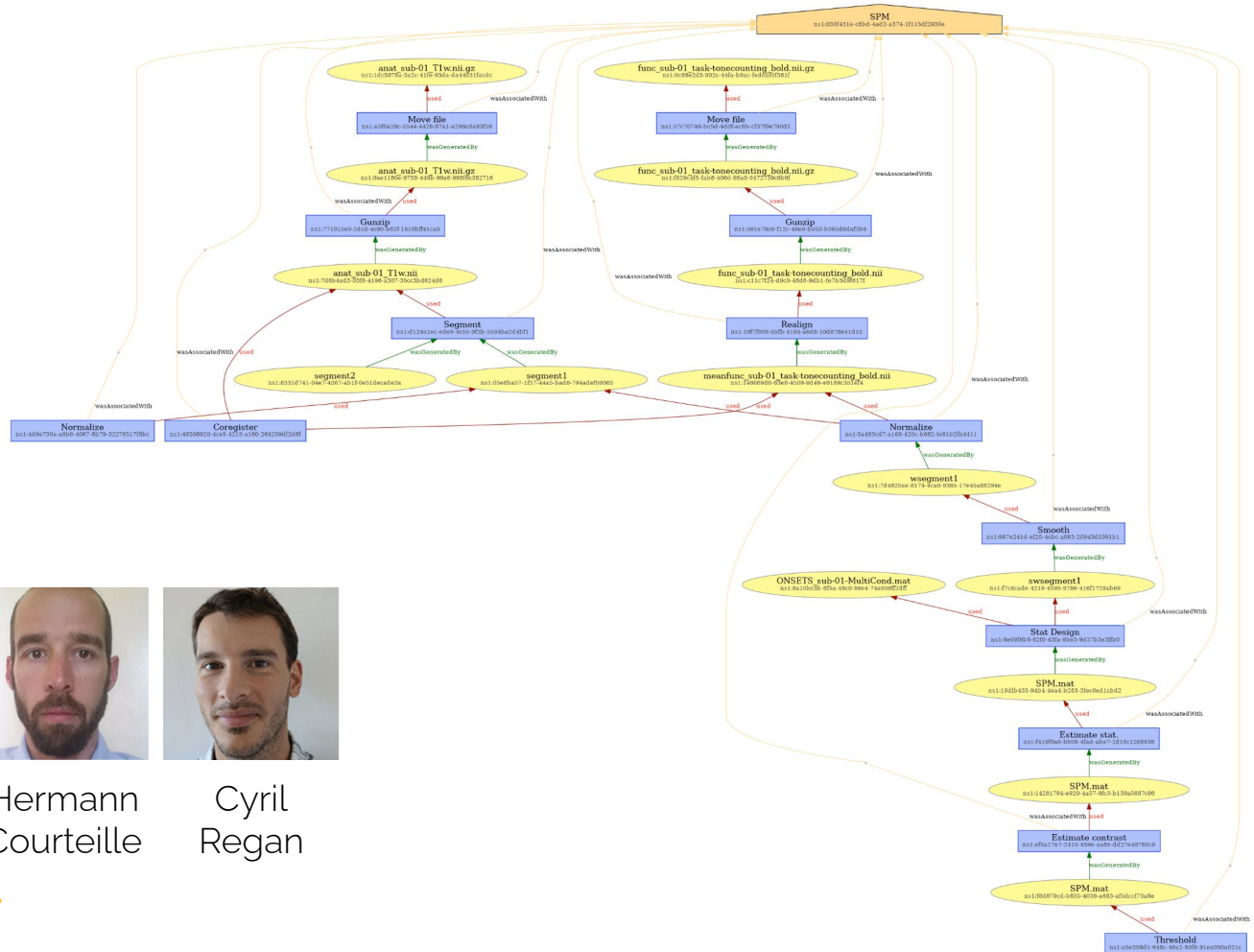
Inputs and outputs (files)

Real world examples

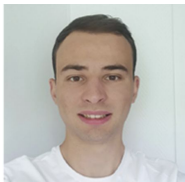
https://github.com/bids-standard/BEPo28_BIDSprov/tree/master/examples/

50+ examples in

- AFNI
- FSL
- SPM



Rémi Adon



Thomas Betton



Hermann Courteille



Cyril Regan

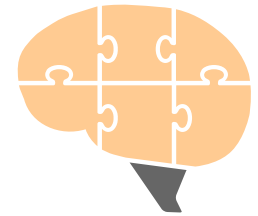
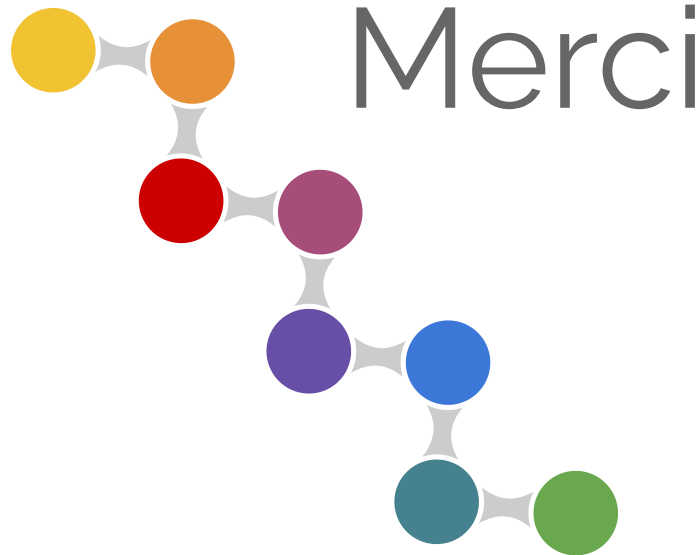
3ème Rencontres Sept 26-28, 2023

Ligne DevTech en Santé Numérique



Tracer la provenance des données de neuroimagerie : est-ce vraiment utile ?

Camille Maumet



 @cmaumet@fediscience.org

Credit: Presentation template and icons by SlidesCarnival, adapted

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