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## Reviewing neuroimaging flexibility: Components and records of provenance

Camille Maumet

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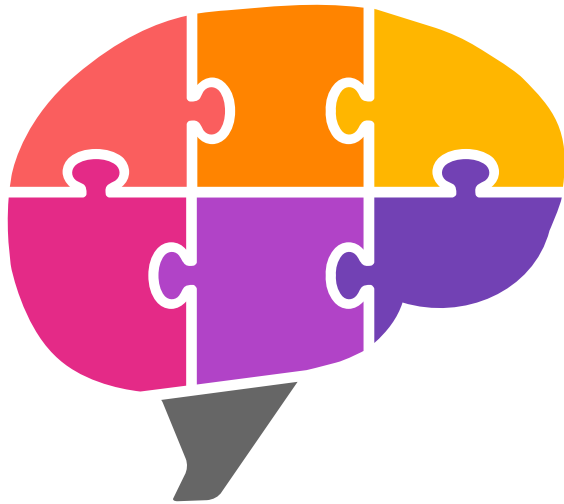
**<https://hal.inria.fr/hal-03705748>**

Submitted on 27 Jun 2022

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*Symposium* What should we do with  
neuroimaging analytical flexibility?



# Reviewing neuroimaging flexibility

Components and records of provenance

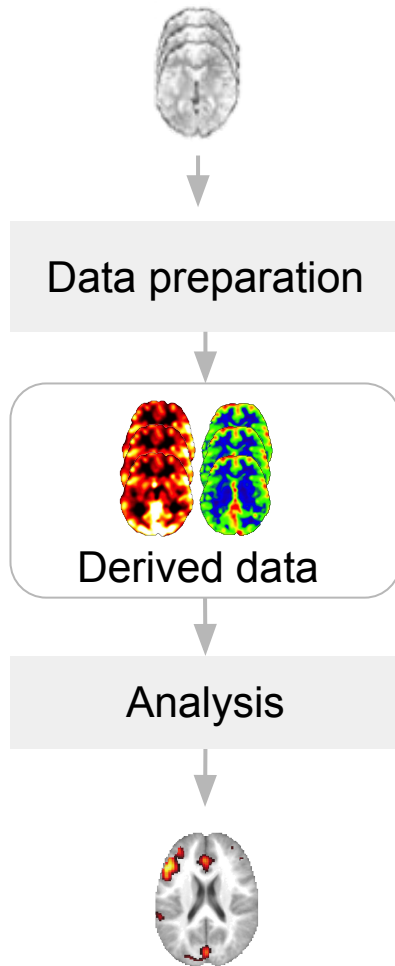
Camille Maumet

Inria, Univ Rennes, Inserm, CNRS, IRISA

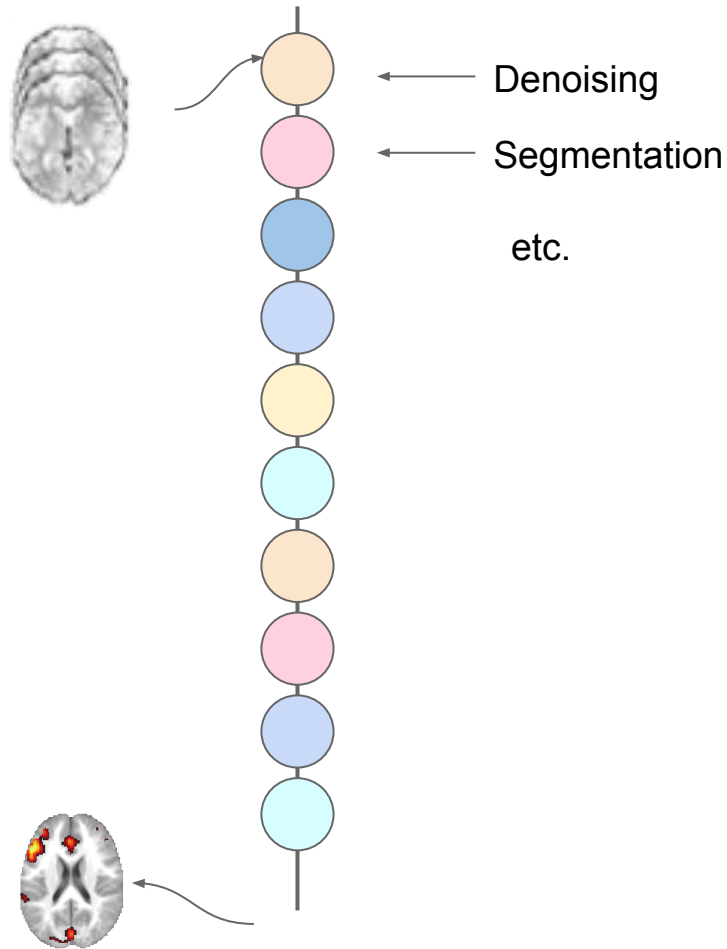


# Different types of **analytical variations**

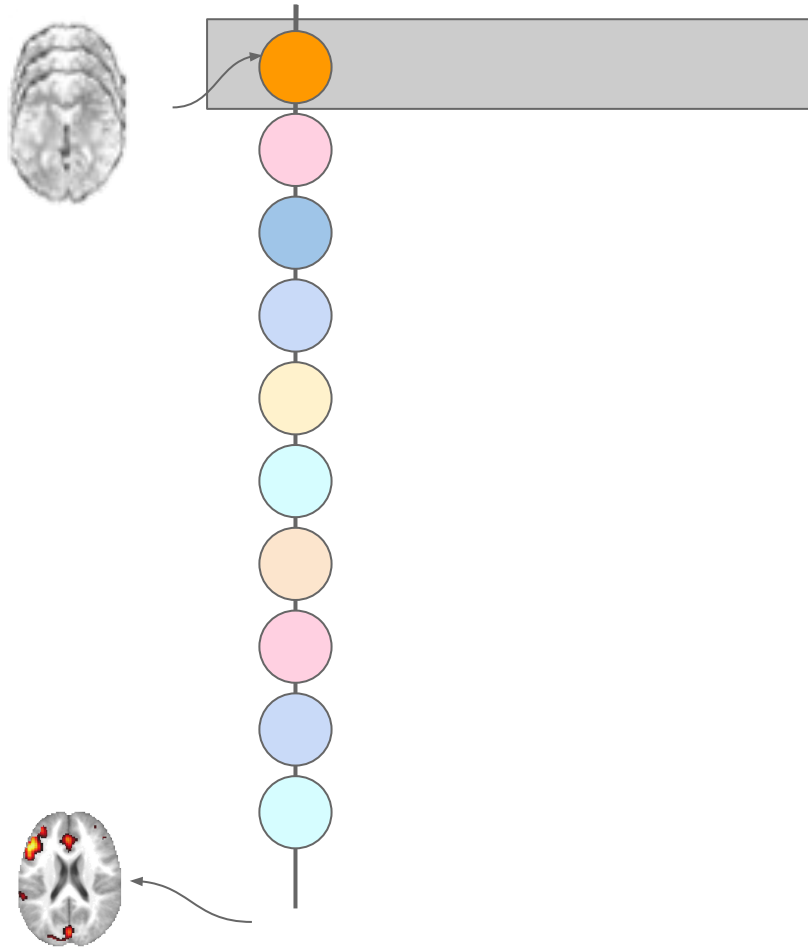
# Types of analytical variations



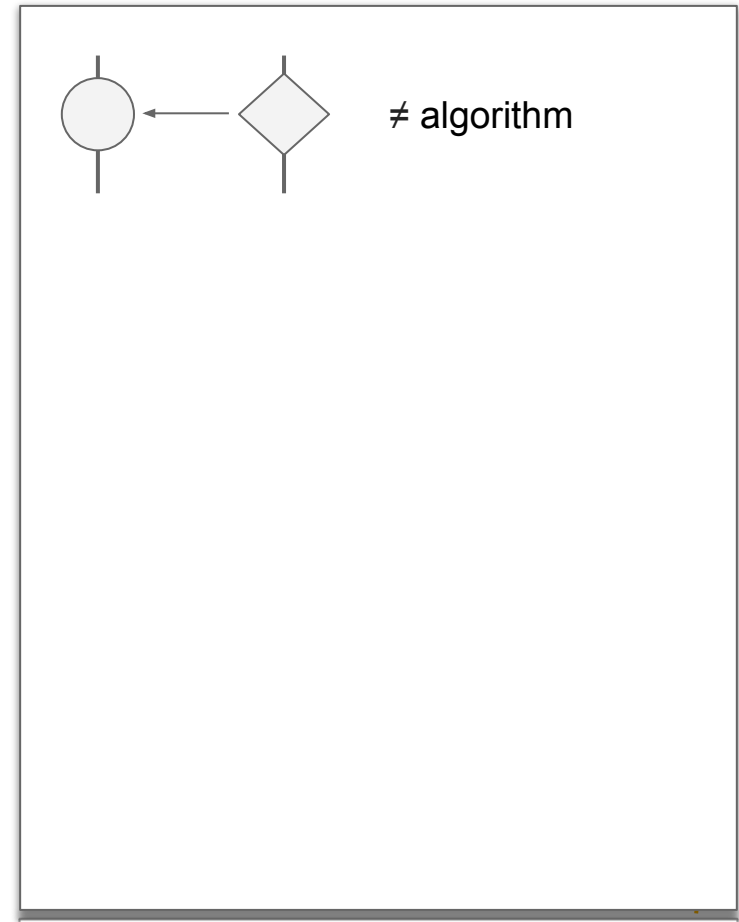
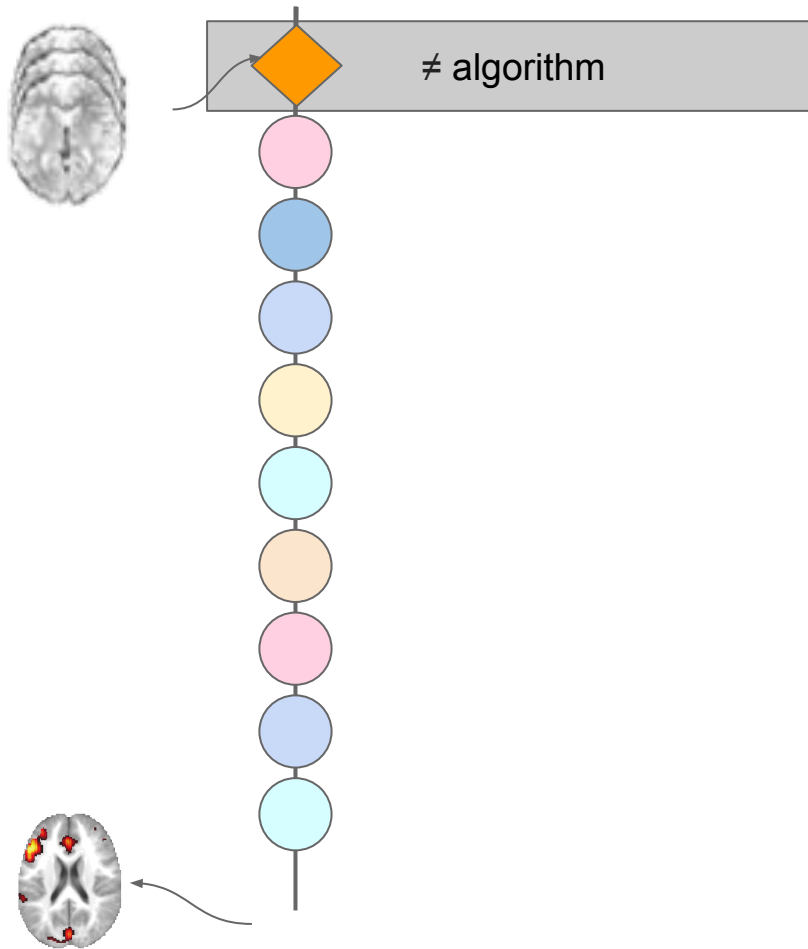
# Types of analytical variations



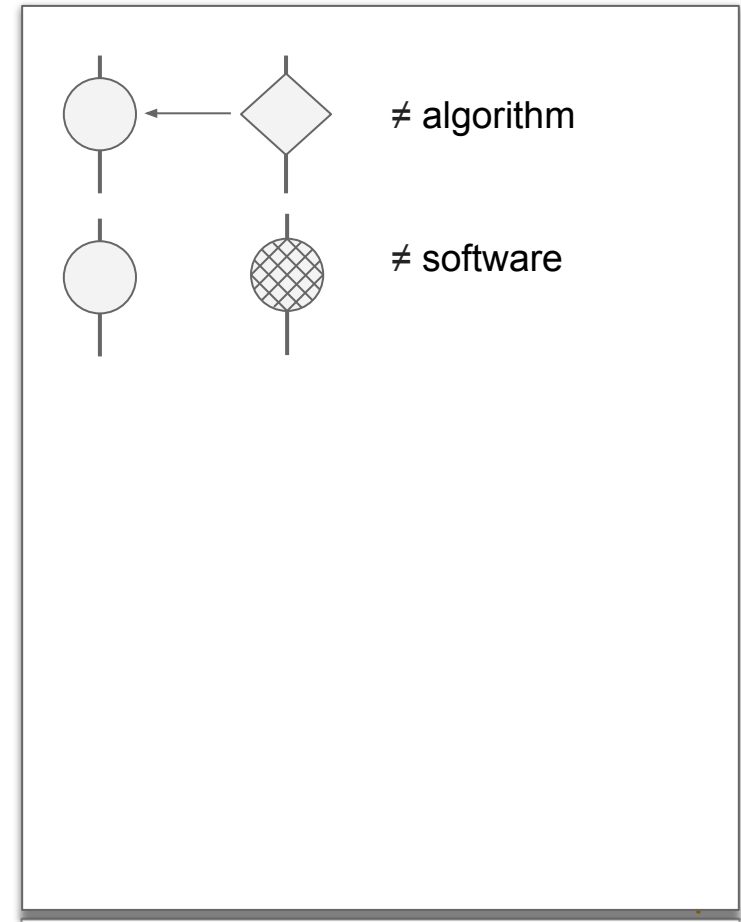
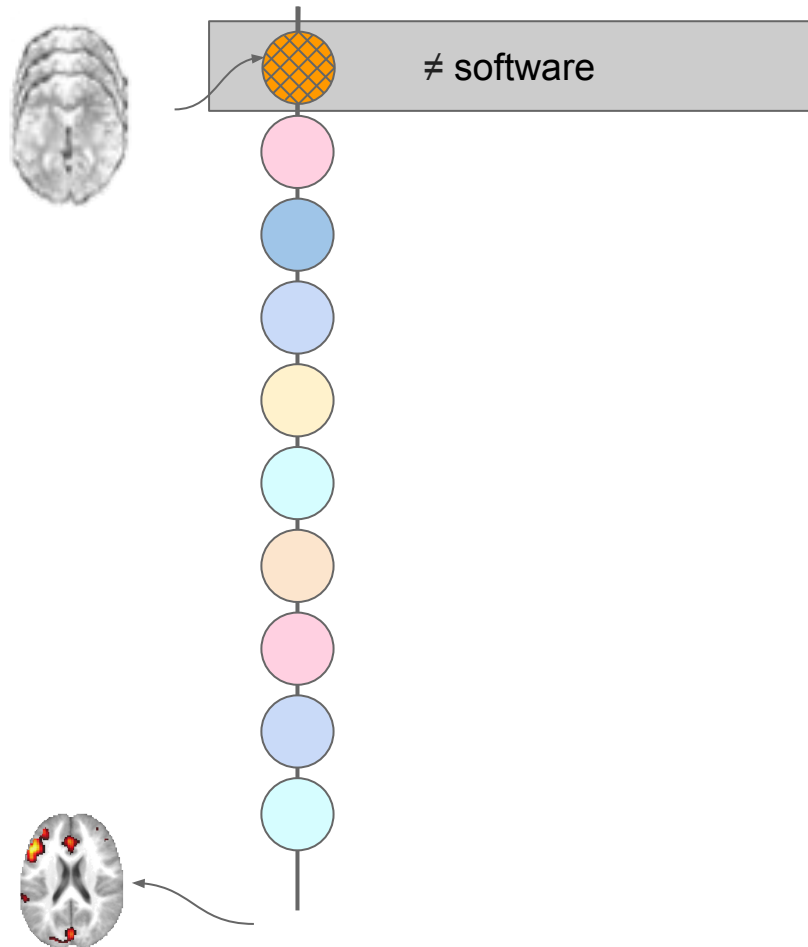
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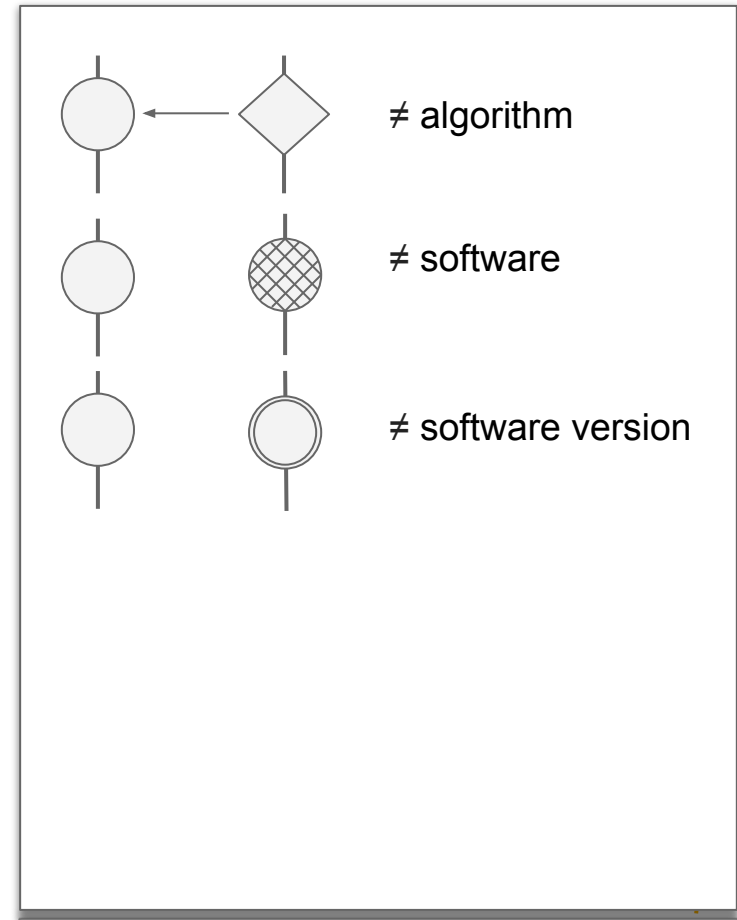
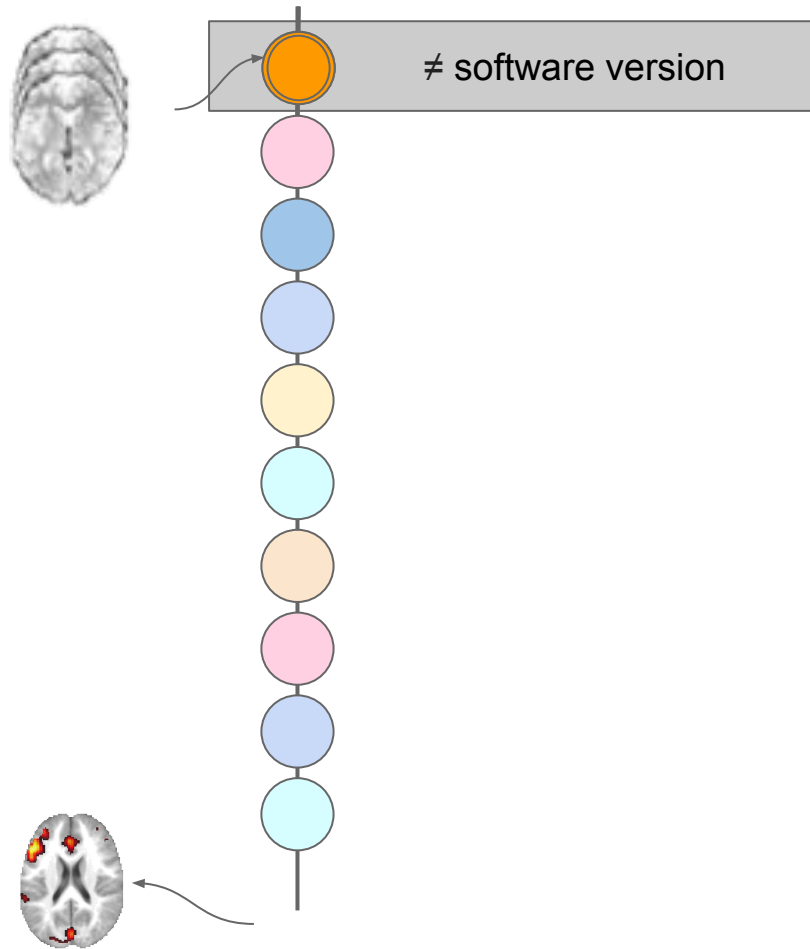


# Types of analytical variations

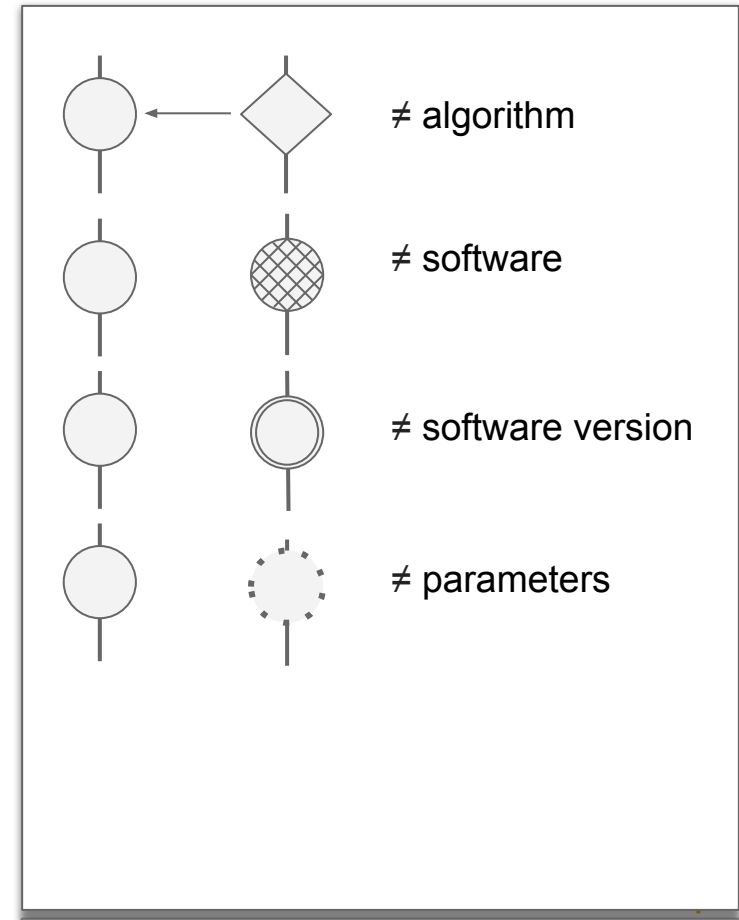
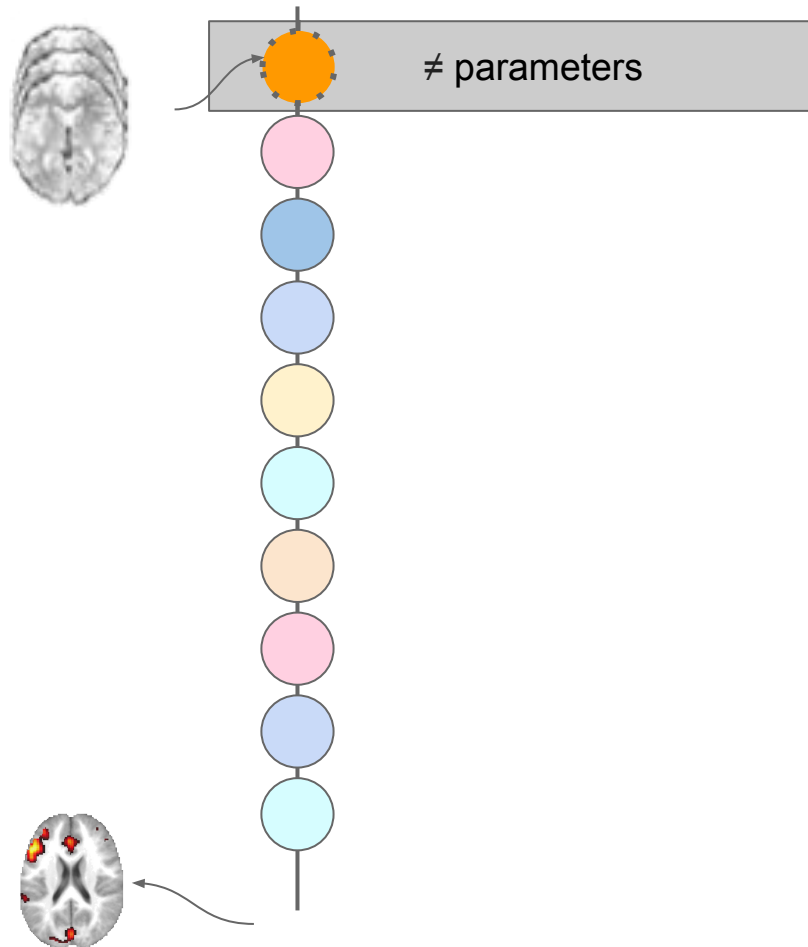




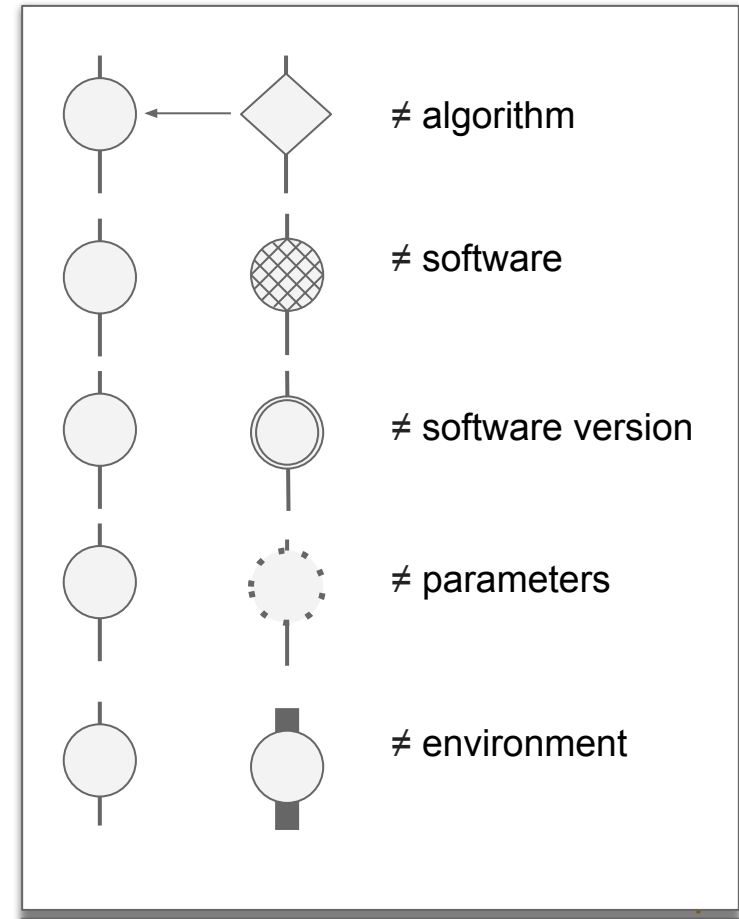
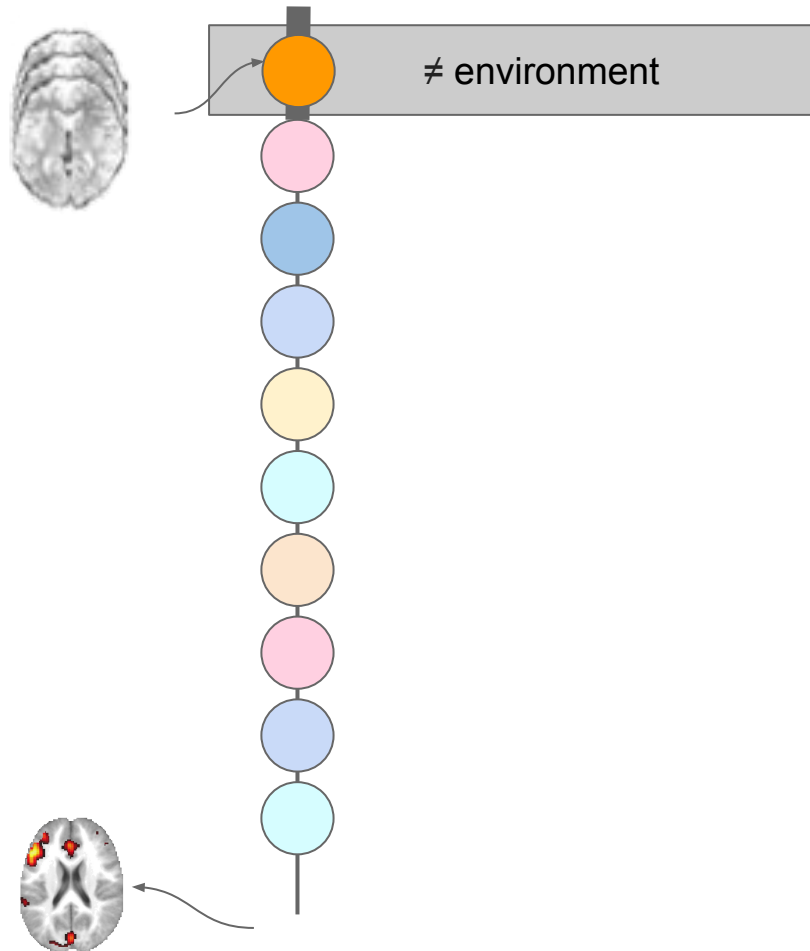
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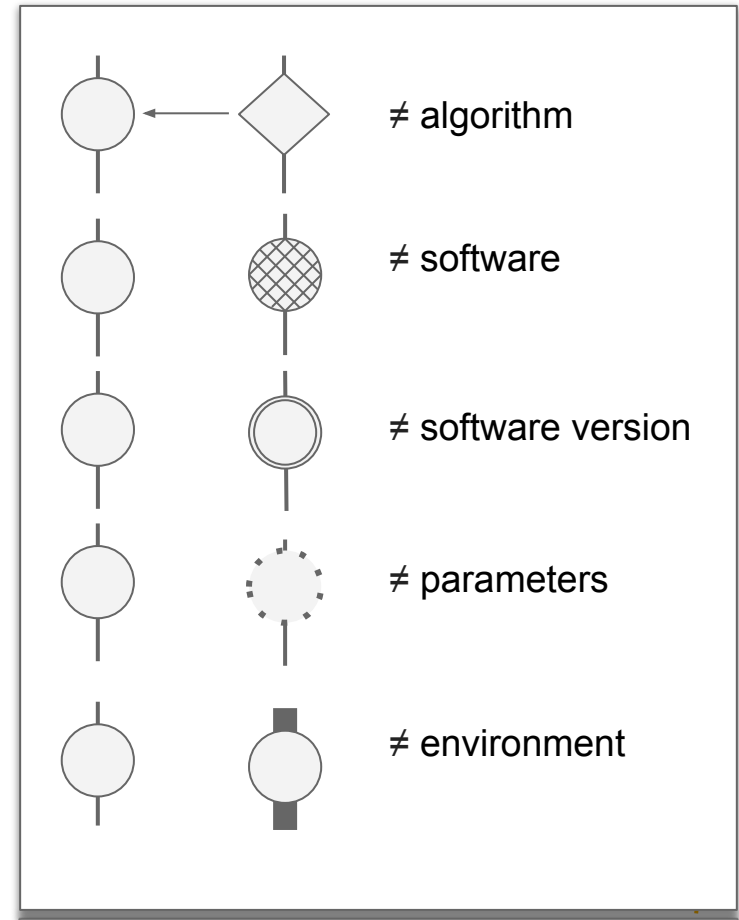
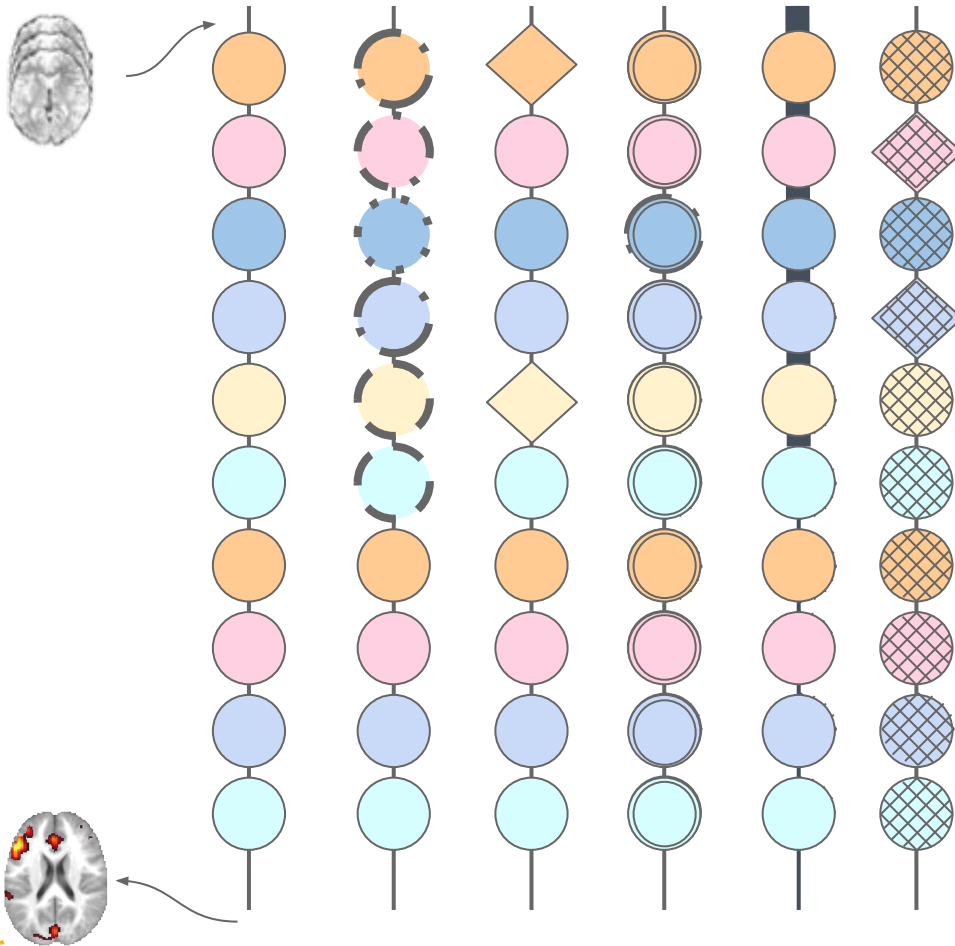
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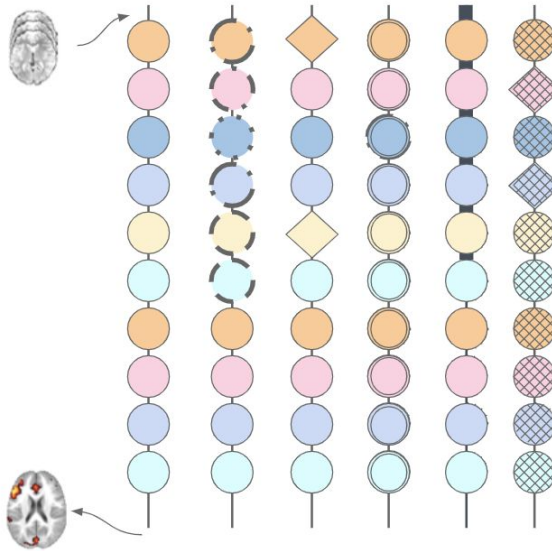
**Can we explain** this  
analytical variability?

# Why is it useful to study analytical variability?

- Impacts the **reliability** of existing findings
- Impacts the **reusability** of derived datasets

# Explaining analytical variability...

?



# Explaining analytical variability...

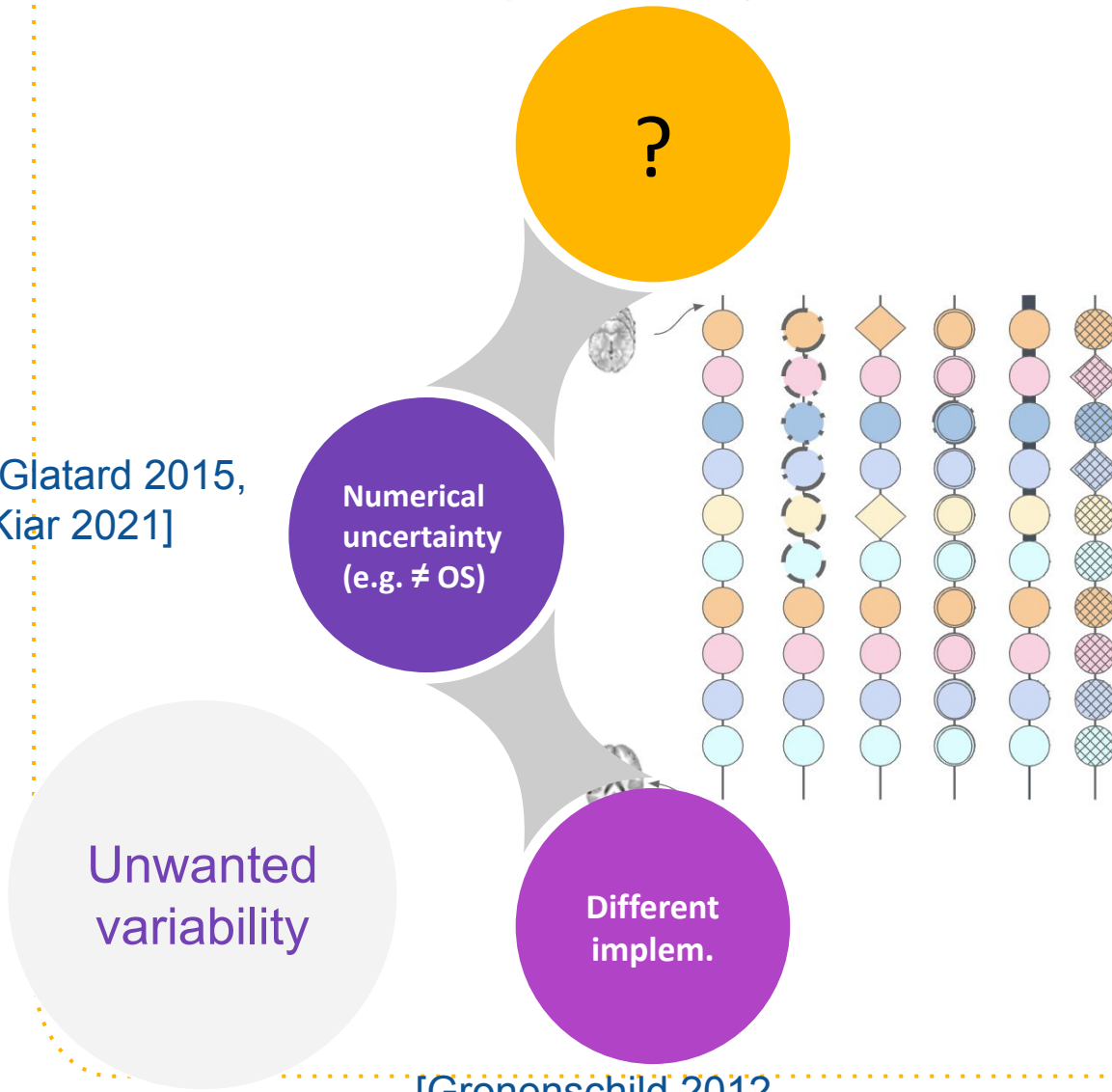
[Glatard 2015,  
Kiar 2021]

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

Unwanted  
variability

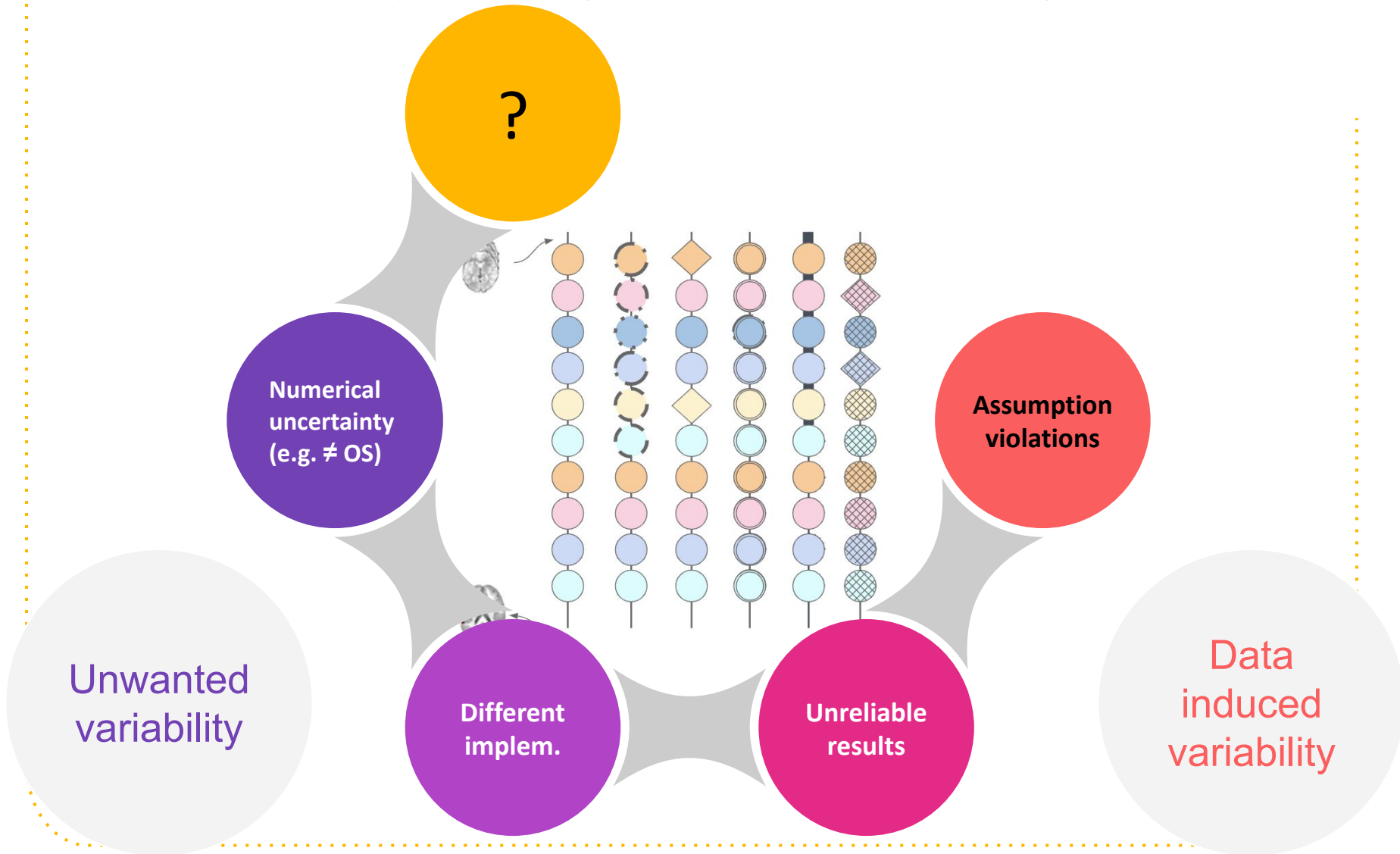
Different  
implem.

[Gronenschild 2012,  
Bowring 2019]

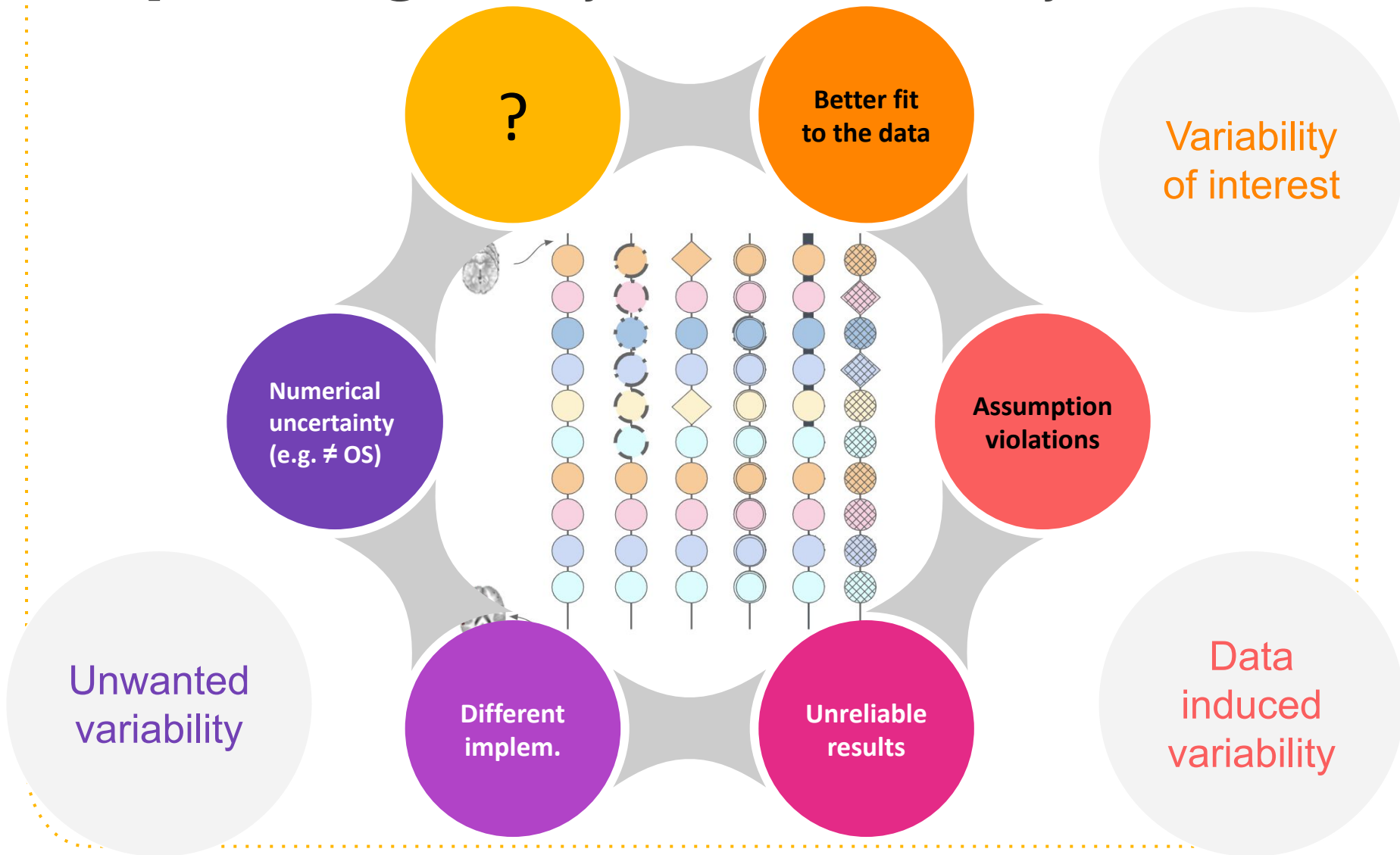




# Explaining analytical variability...



# Explaining analytical variability...

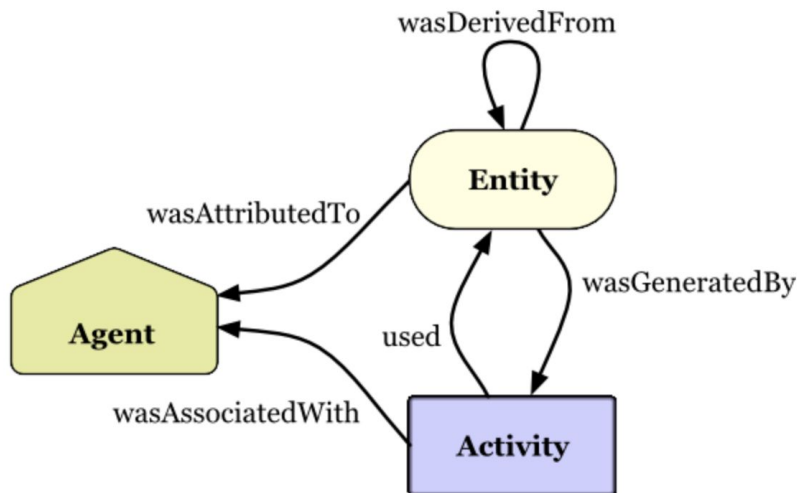


How can **recording  
provenance** help  
manage analytical  
variability?

# Provenance

“**Provenance** describe how an artifact or set of artifacts was produced” [Wikipedia](#)

“**Provenance** is information about entities, activities, and people involved in producing a piece of data [...]” [W3C PROV.](#)



W3C PROV model

<https://www.w3.org/TR/2013/NOTE-prov-primer-20130430/>

# Provenance Use Case 1 **An unambiguous description of the methods**



# Provenance Use Case 1 **An unambiguous description of the methods**



Which release of SPM was used?

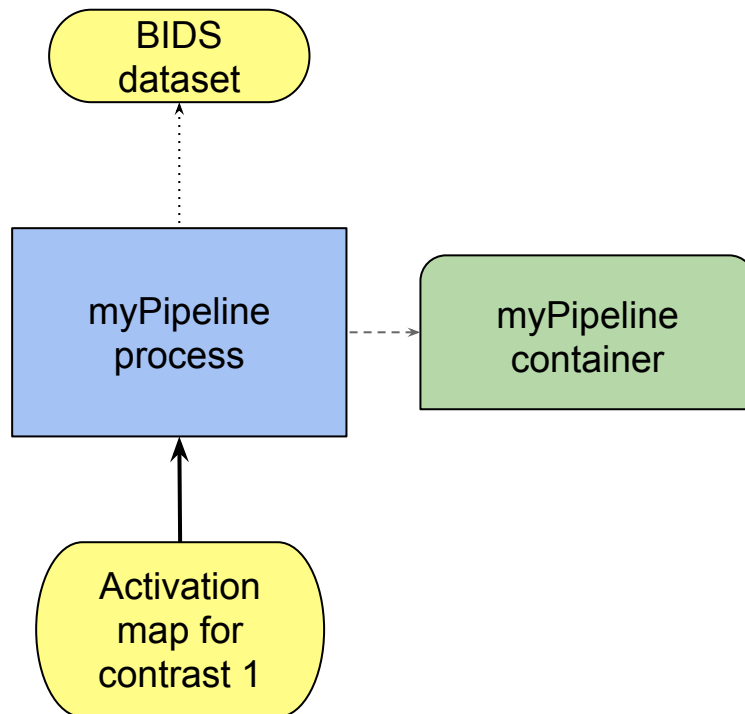
Which registration algorithm was selected?

How was the brain mask computed?

Provenance Use Case 1 **An unambiguous  
description of the methods**

Can we  
**reproduce**  
**exactly the same**  
**results**  
(same data, same  
methods)?

# Provenance Use Case 1 **An unambiguous description of the methods**



Can we  
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Provenance Use Case 2 **Dealing with  
unwanted variability**

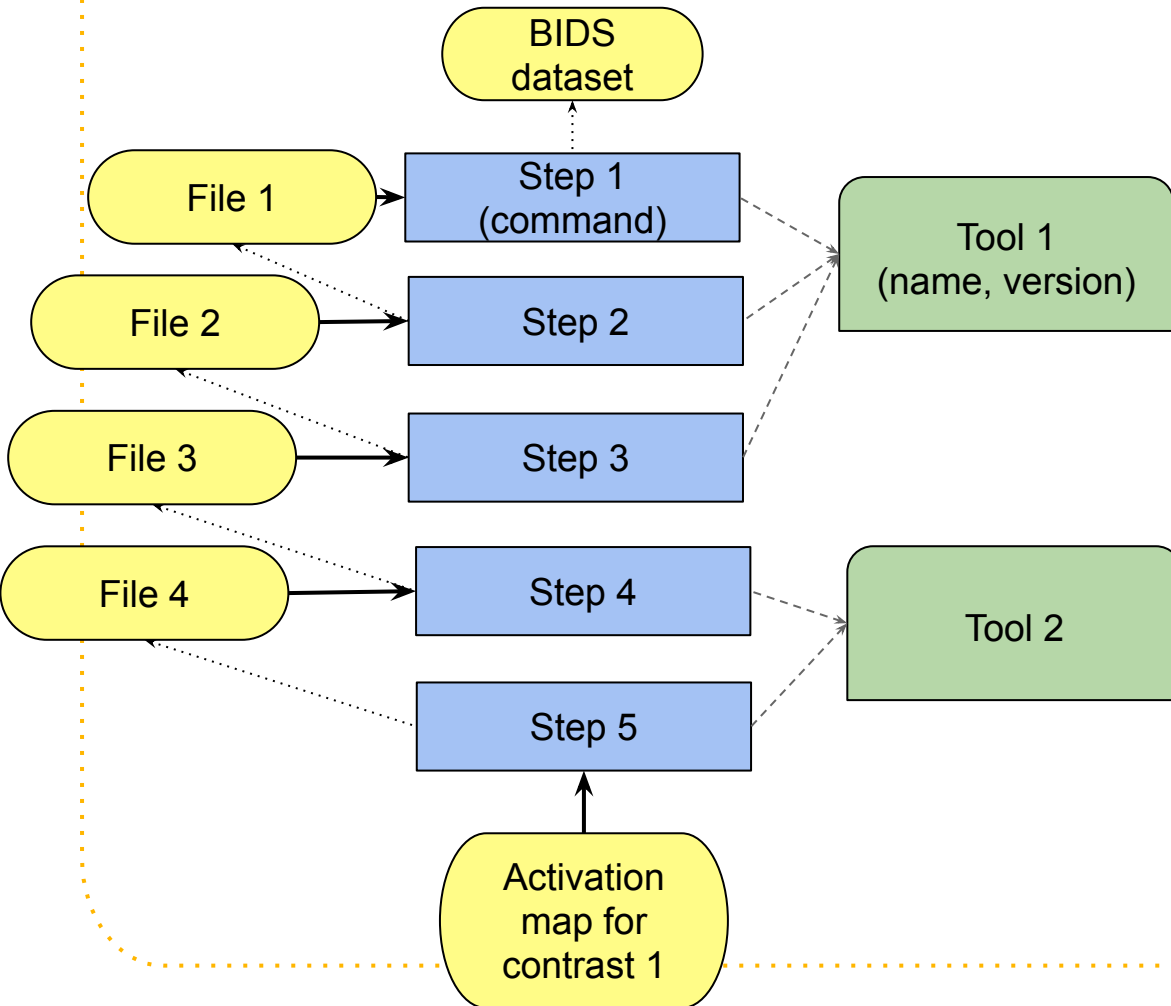
A previously  
widely-used  
**parameter is no  
longer considered  
as best practice**

## Provenance Use Case 2 **Dealing with unwanted variability**

A previously widely-used **parameter is no longer considered as best practice**

A bug was found in a given tool **version**, can we retrieve all corresponding results?

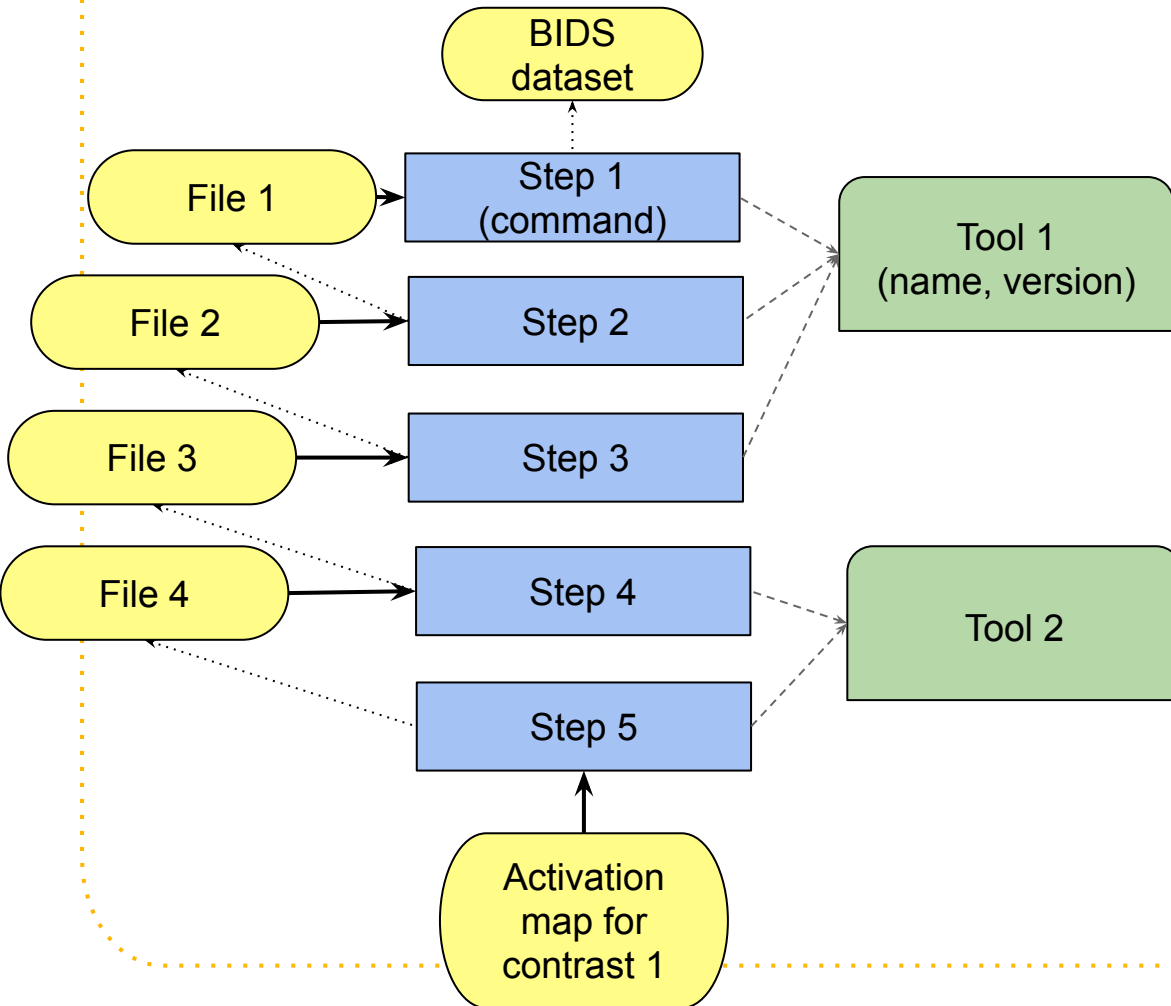
# Provenance Use Case 2 **Dealing with unwanted variability**



A previously widely-used **parameter is no longer considered as best practice**

**A bug was found in a given tool version, can we retrieve all corresponding results?**

# Provenance Use Case 3 **Exploring factors impacting analytical variability**



Low level: Are my conclusions dependant on the **size of the smoothing kernel** used at Step 5?

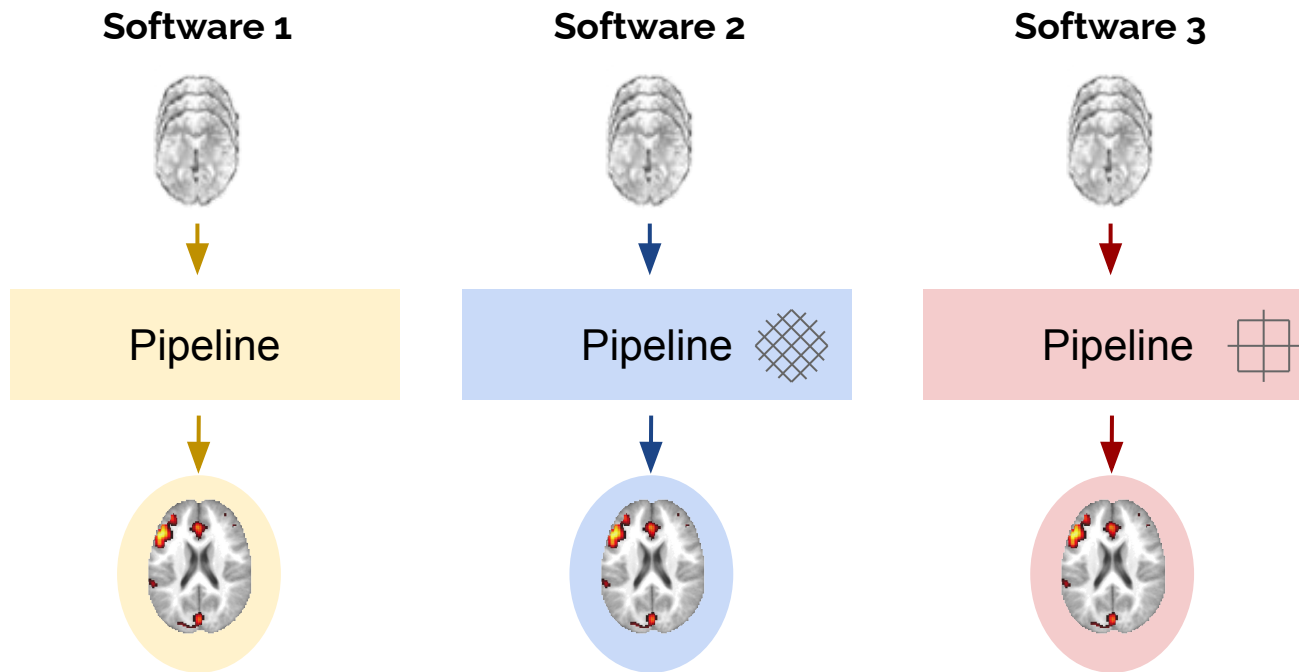
Provenance Use Case 3 **Exploring factors  
impacting analytical variability**

# Variability across software

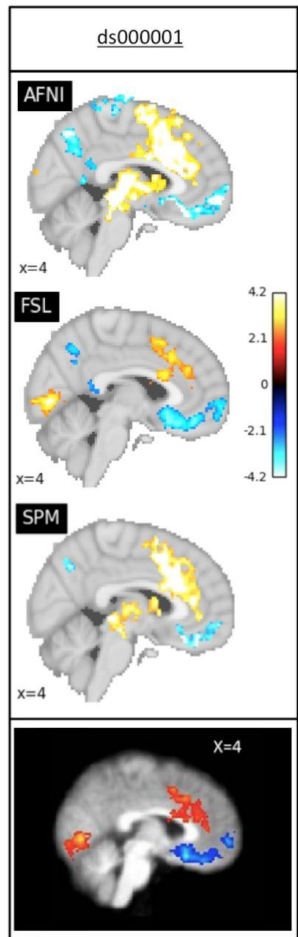
- Reproduced 3 published functional MRI studies
- Using 3 different neuroimaging software packages



Alex Bowring Tom Nichols



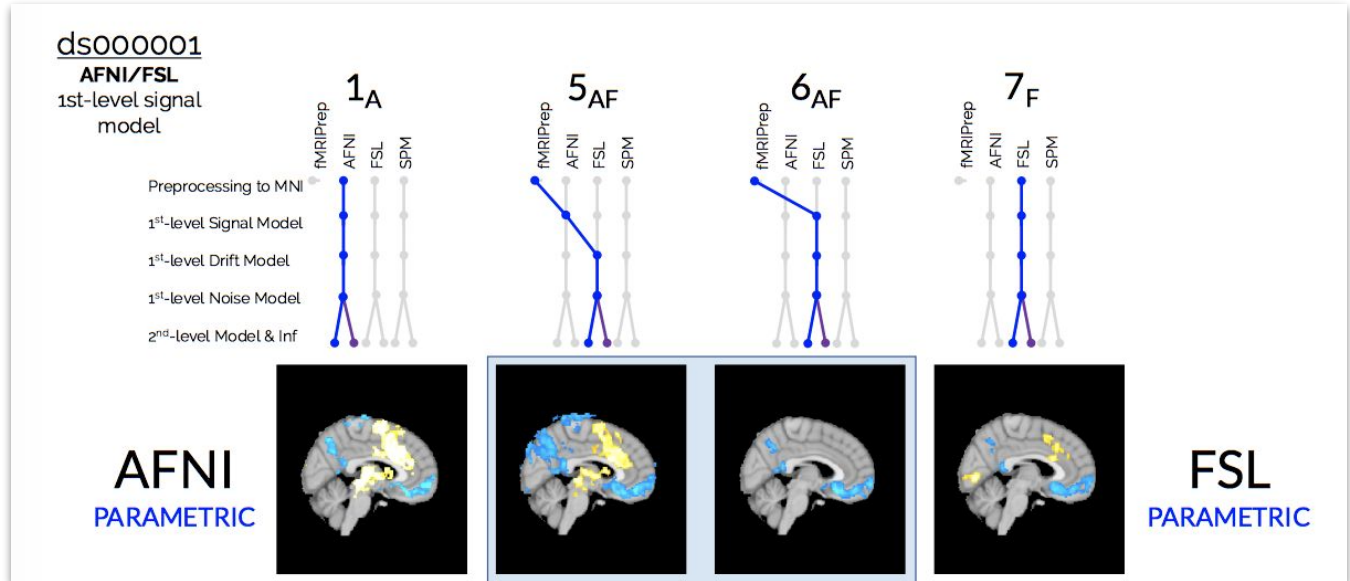
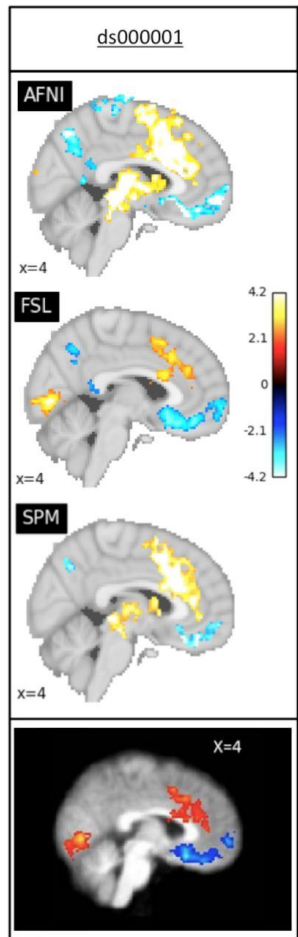
# Variability across software



Thresholded maps in AFNI,  
FSL, SPM + original

[Bowring et. al, HBM 2019]

# Variability across software



[Bowring et. al, HBM 2021]

Thresholded maps in AFNI,  
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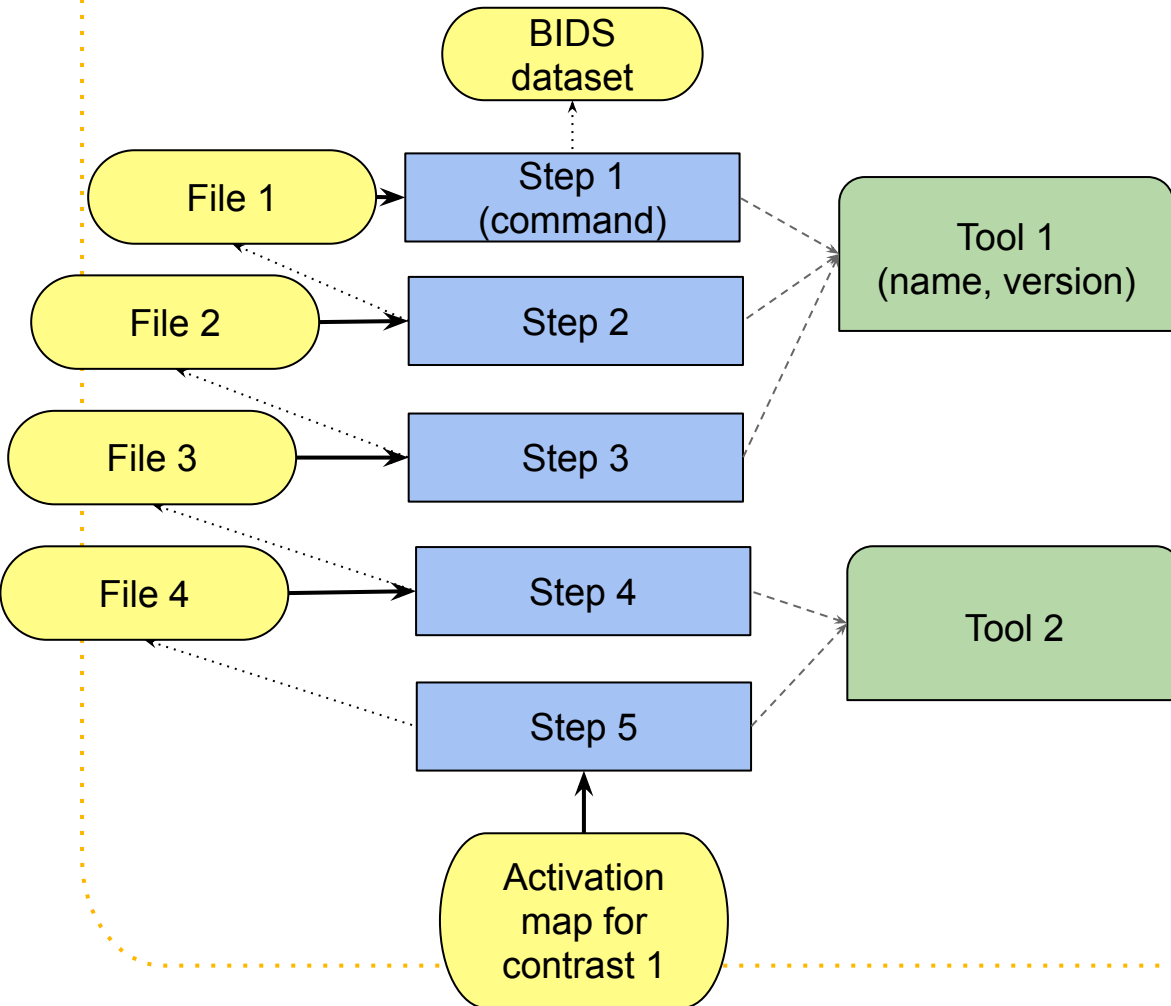
[Bowring et. al, HBM 2019]



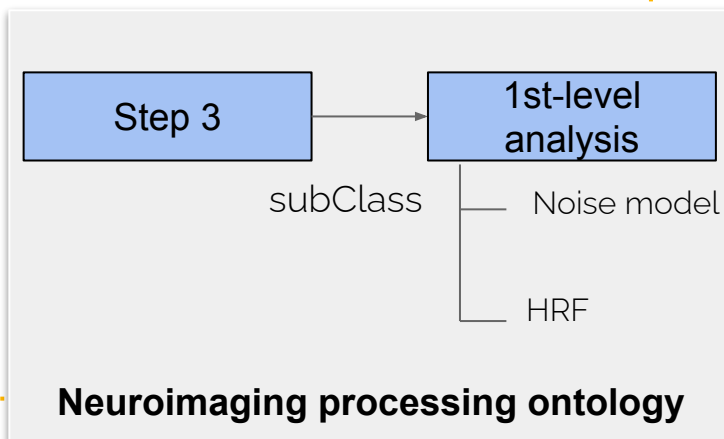
Provenance Use Case 3 **Exploring factors  
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High level: Are my conclusions dependant on the **type on the noise model** in the 1st-level analysis?

# Provenance Use Case 3 **Exploring factors impacting analytical variability**



High level: Are my conclusions dependant on the **type on the noise model** in the 1st-level analysis?



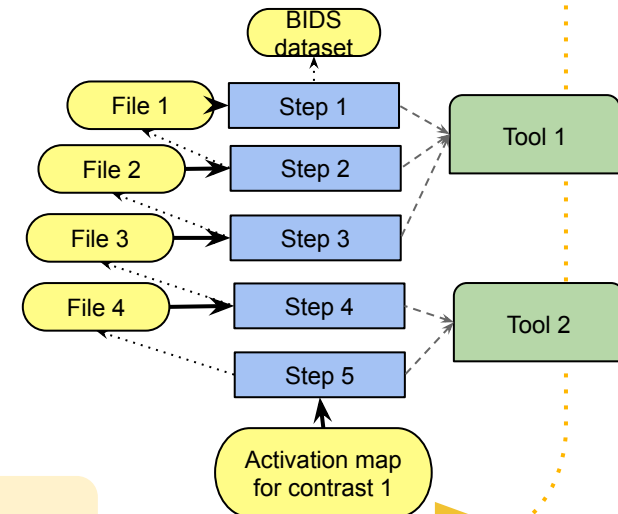
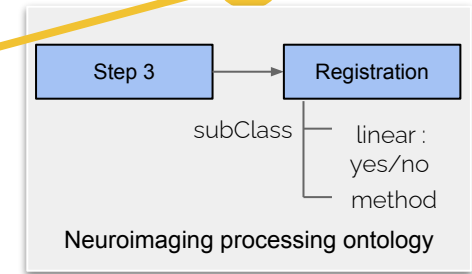
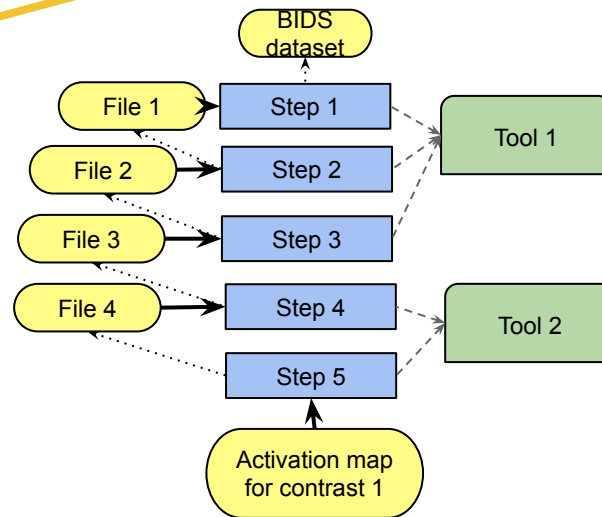
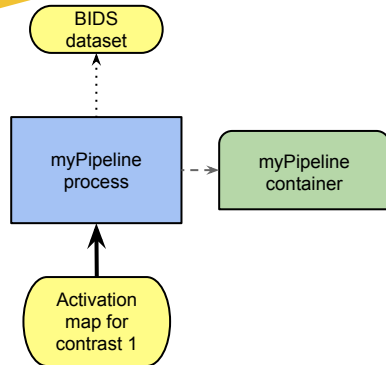
**Neuroimaging processing ontology**

# Recording provenance to help manage analytical variability

Step-level + ontology

Pipeline-level

Step-level



+ Complex / Rich  
+ Use cases

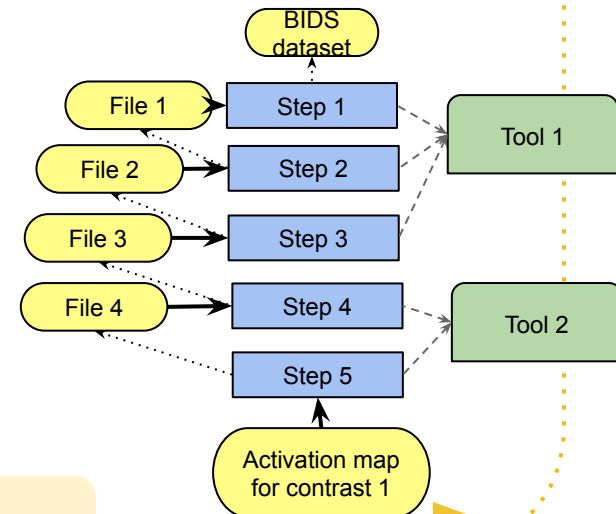
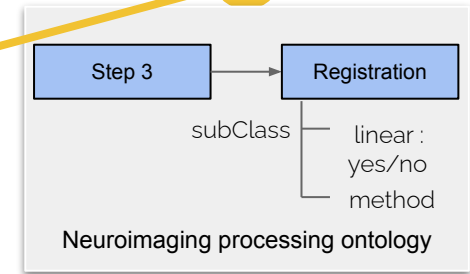
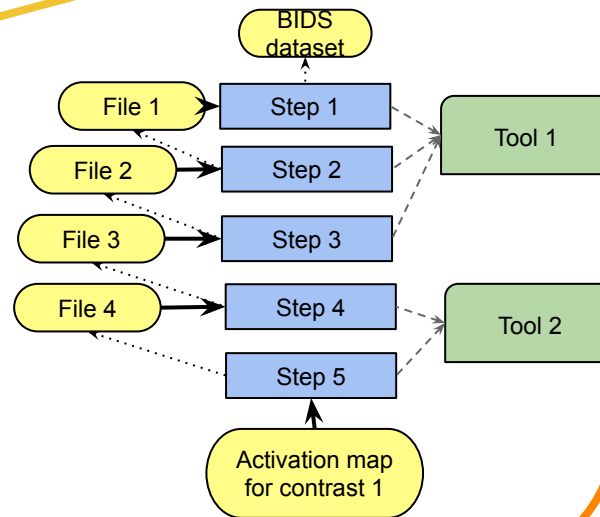
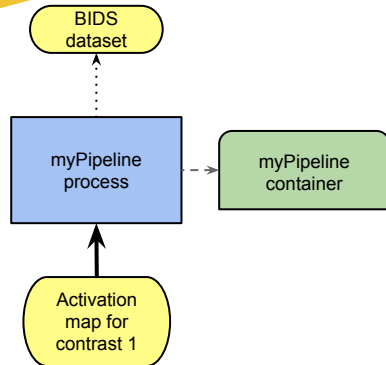
# Recording provenance to help manage analytical variability

Step-level + ontology

BIDS-Prov

Pipeline-level

Step-level



+ Complex / Rich  
+ Use cases

**BIDS-Prov**



enabling open and  
FAIR neuroscience

# BIDS Extension Proposal 28

**Moderators:** Satra Ghosh et Camille Maumet

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

# Thank you!

BIDS-Prov is open for community feedback

[https://github.com/bids-standard/BEP028\\_BIDSprov](https://github.com/bids-standard/BEP028_BIDSprov)

**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

Symposium What should we do with neuroimaging analytical flexibility?



# Reviewing neuroimaging flexibility

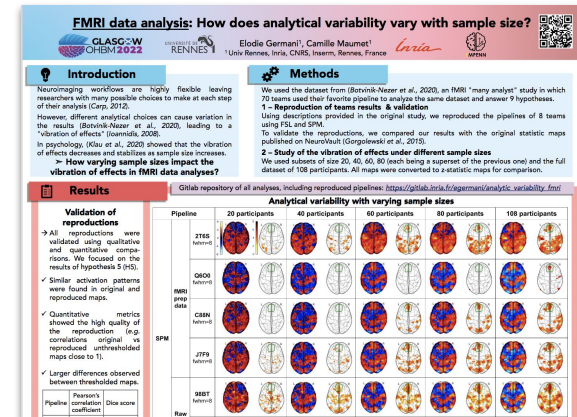
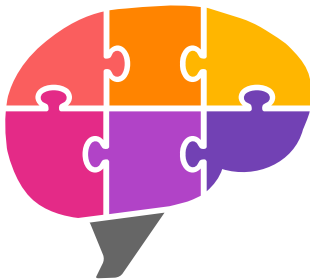
Components and records of provenance

Camille Maumet



**Poster WTh872** *How does analytical variability vary with sample sizes?* **Elodie Germani**

# Thank you!



**We are hiring!**

<https://team.inria.fr/empenn/job-offers/>

Credit: Presentation template and icons by SlidesCarnival, adapted

