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Reviewing neuroimaging flexibility: Components and records of provenance

Camille Maumet

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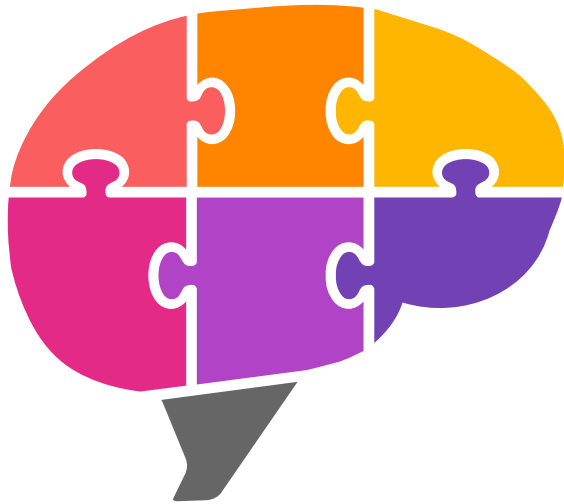
<https://inria.hal.science/hal-03705748>

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

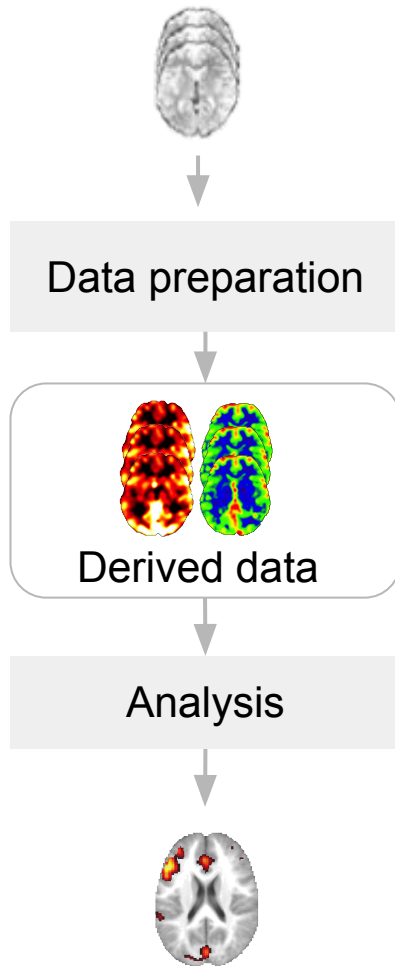
Camille Maumet

Inria, Univ Rennes, Inserm, CNRS, IRISA

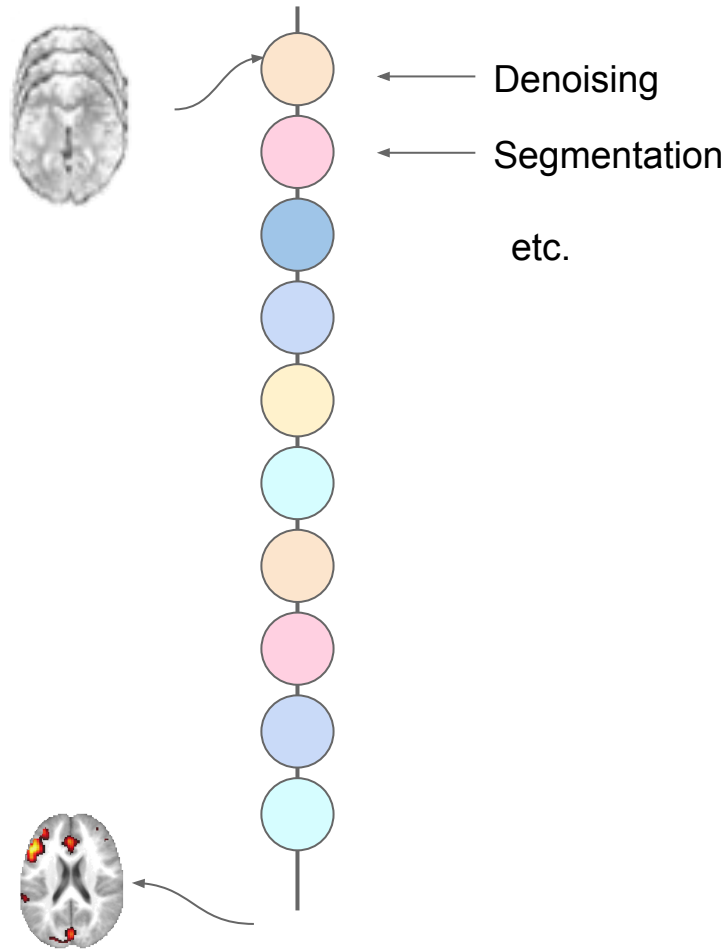


Different types of **analytical variations**

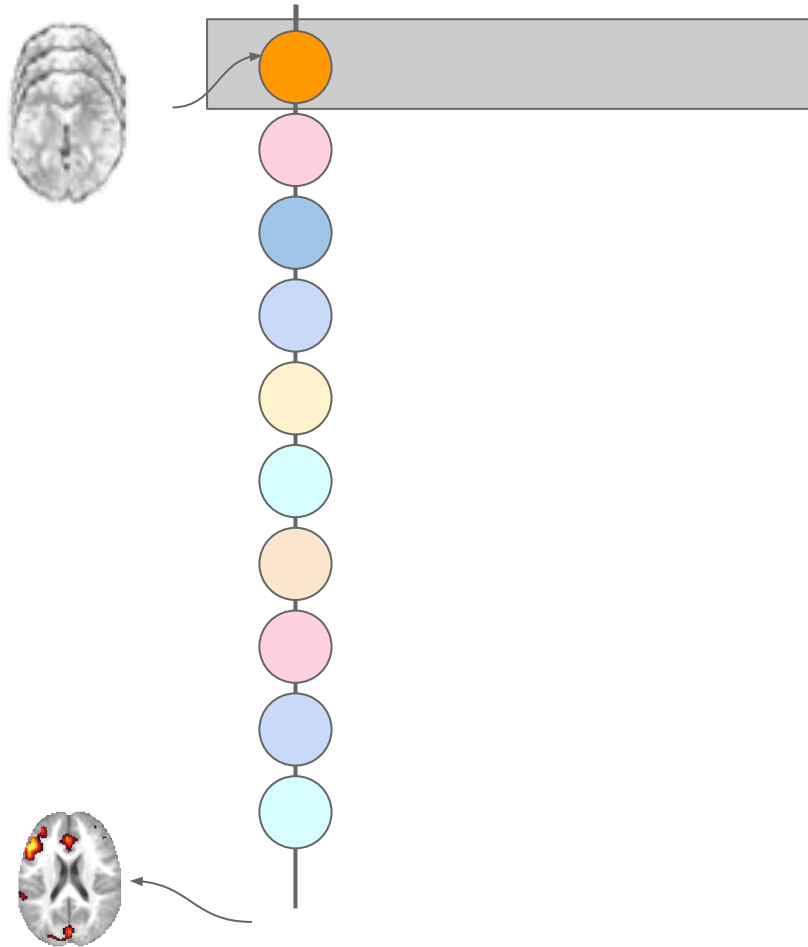
Types of analytical variations



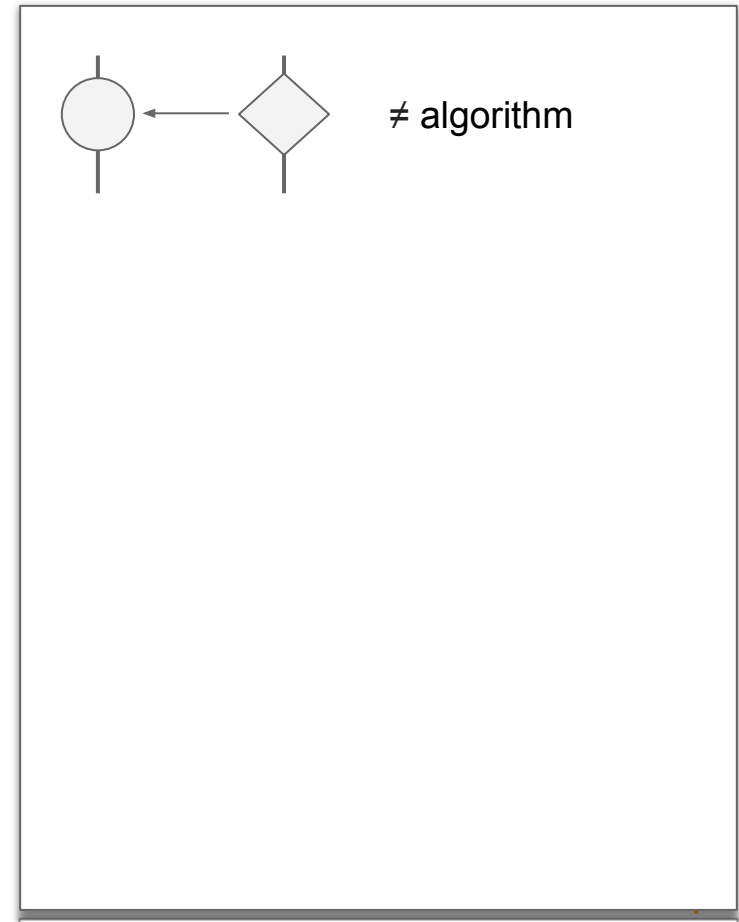
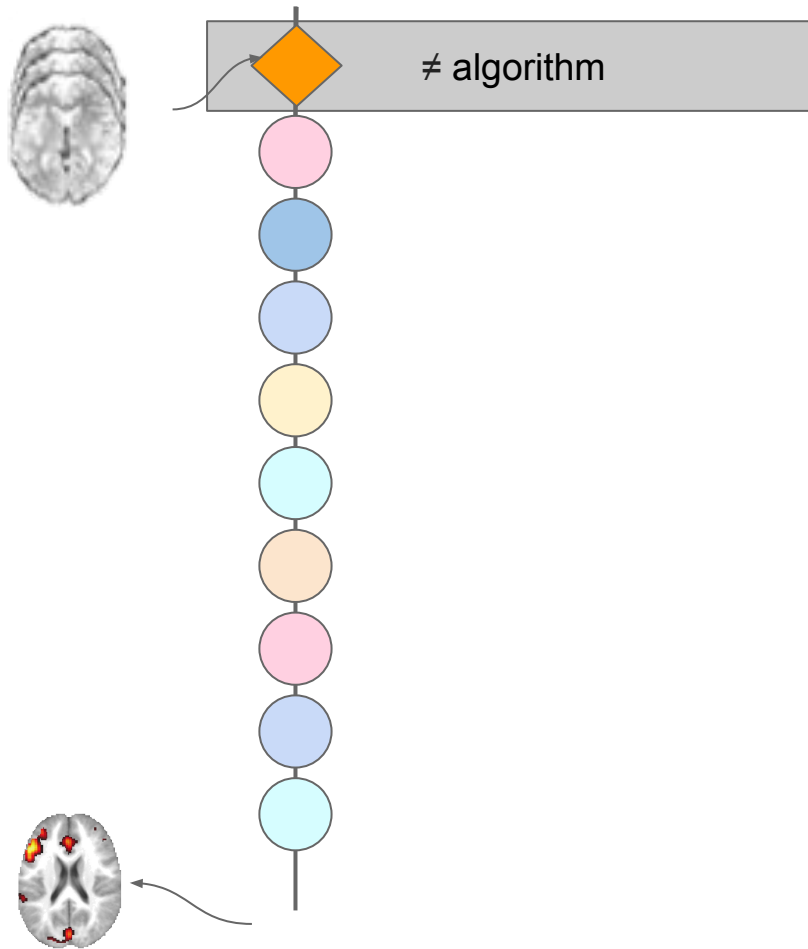
Types of analytical variations



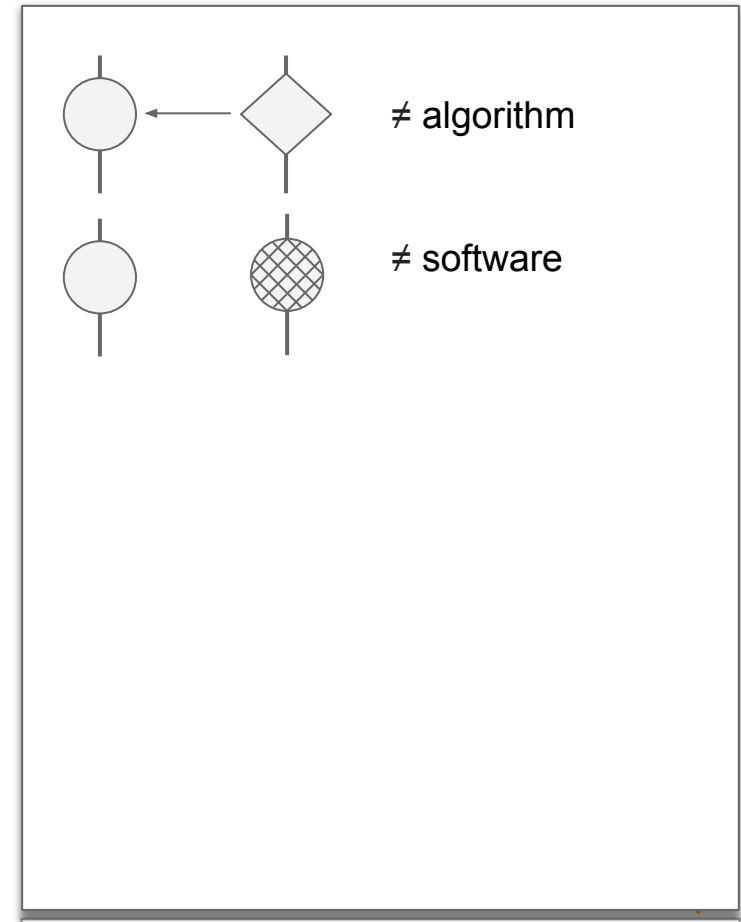
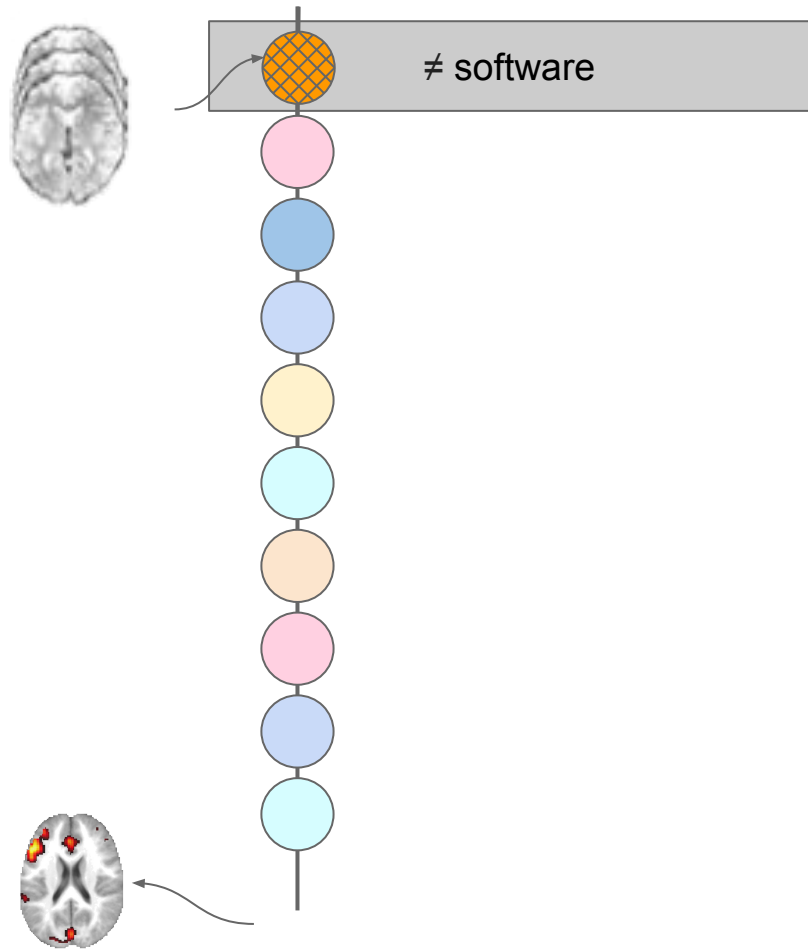
Types of analytical variations



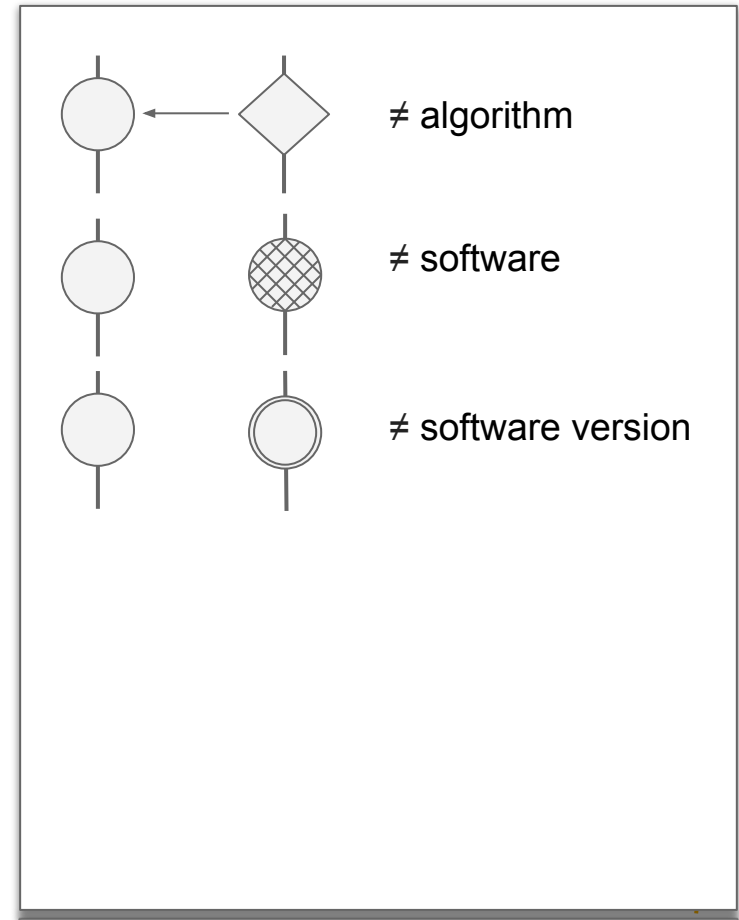
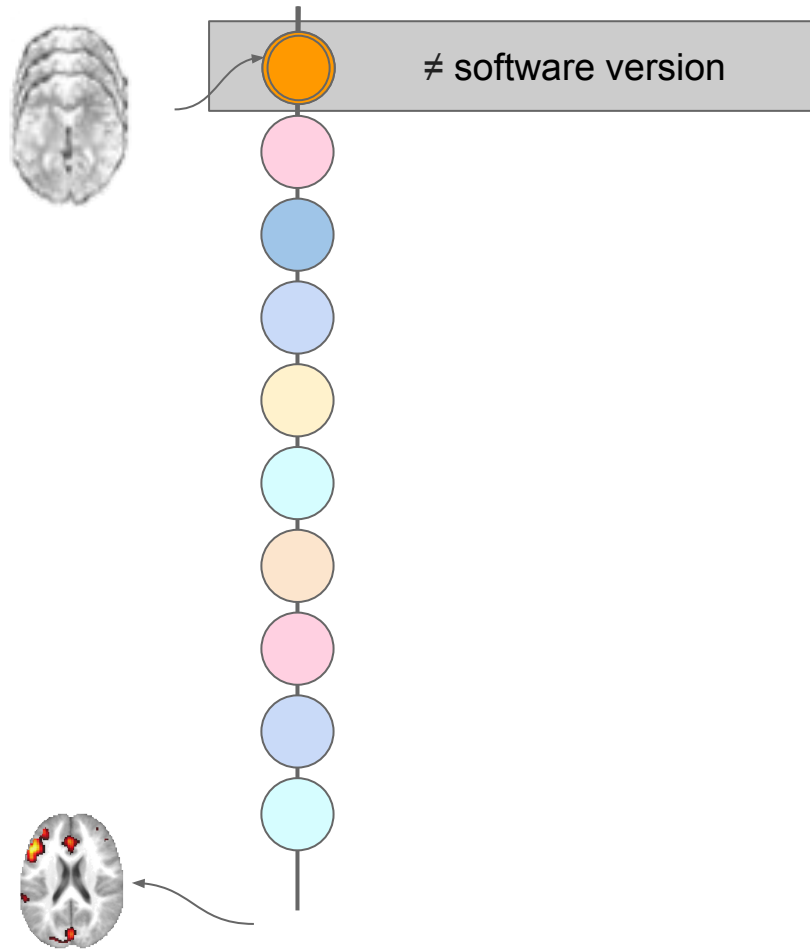
Types of analytical variations



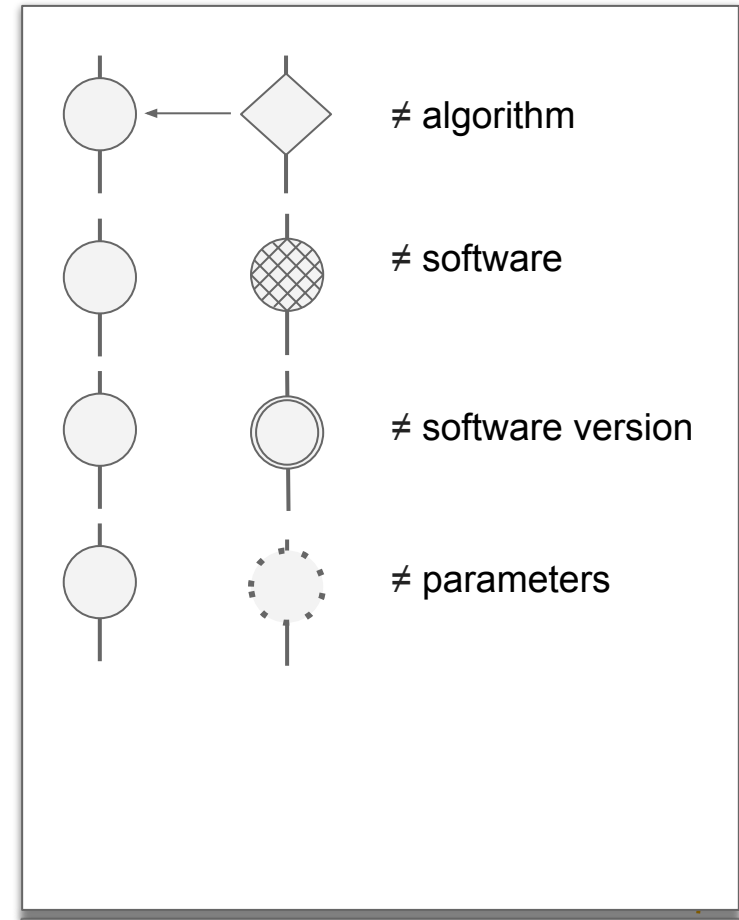
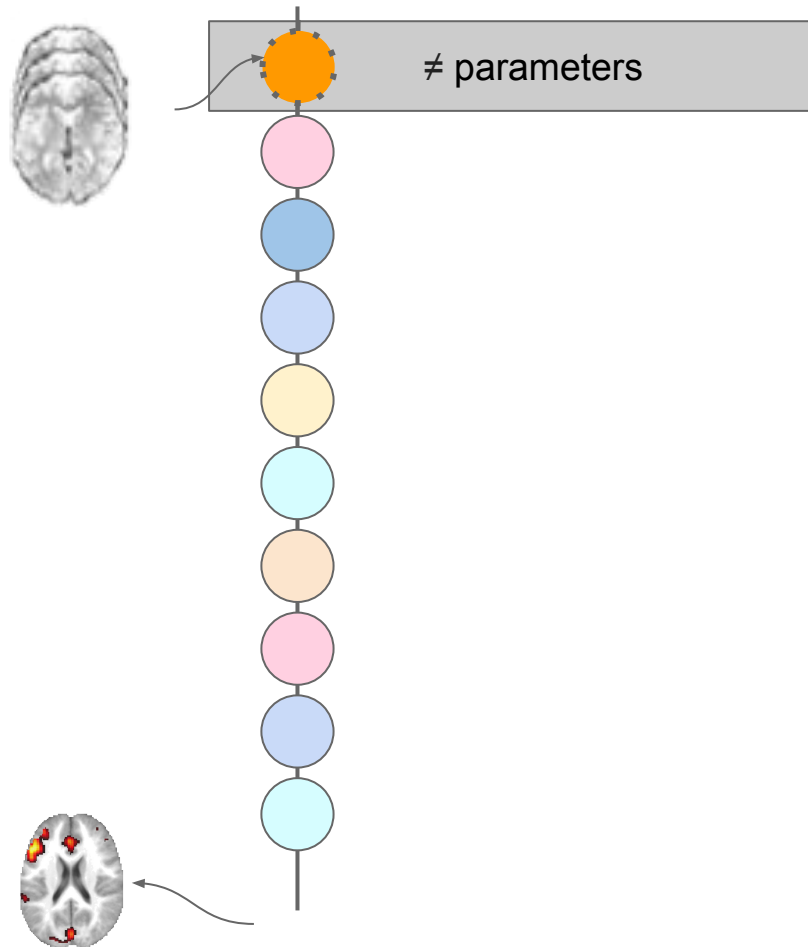
Types of analytical variations



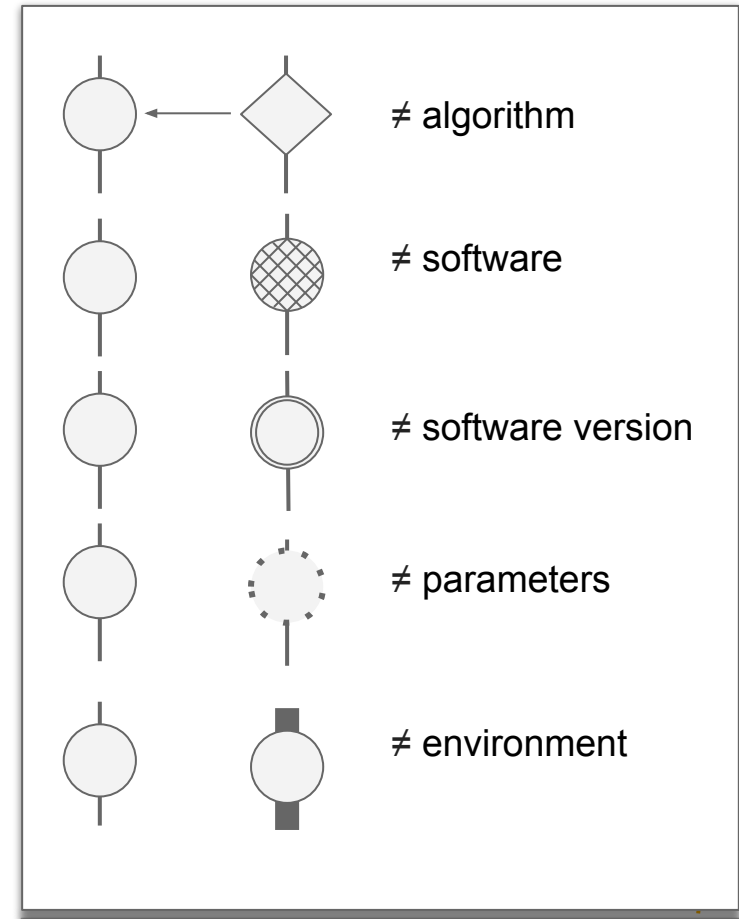
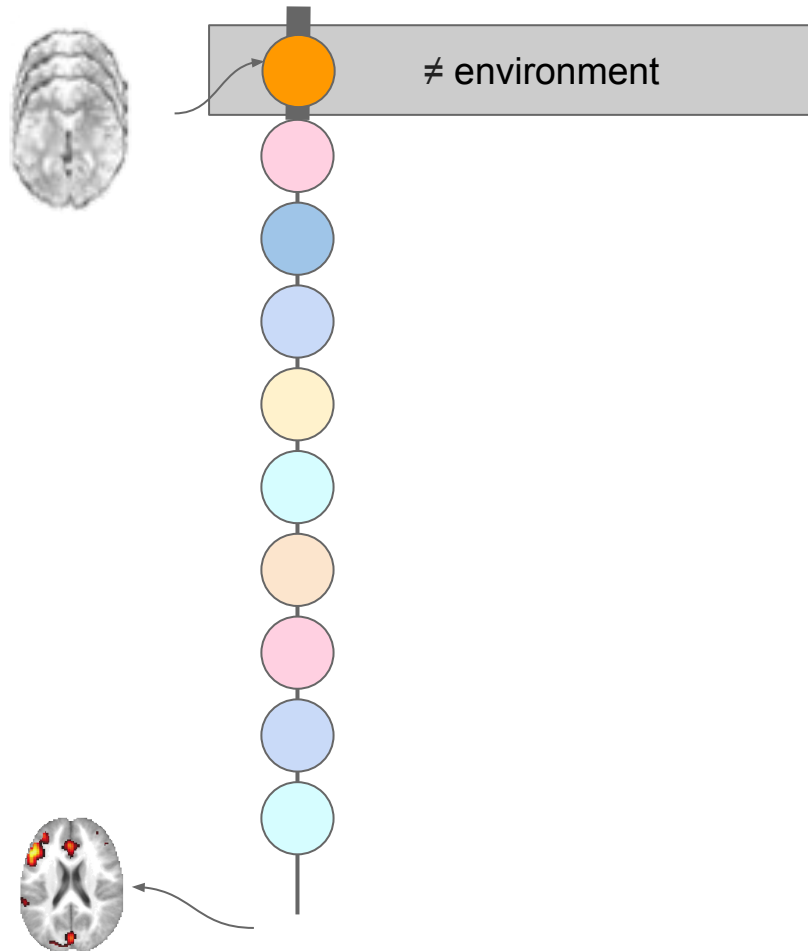
Types of analytical variations



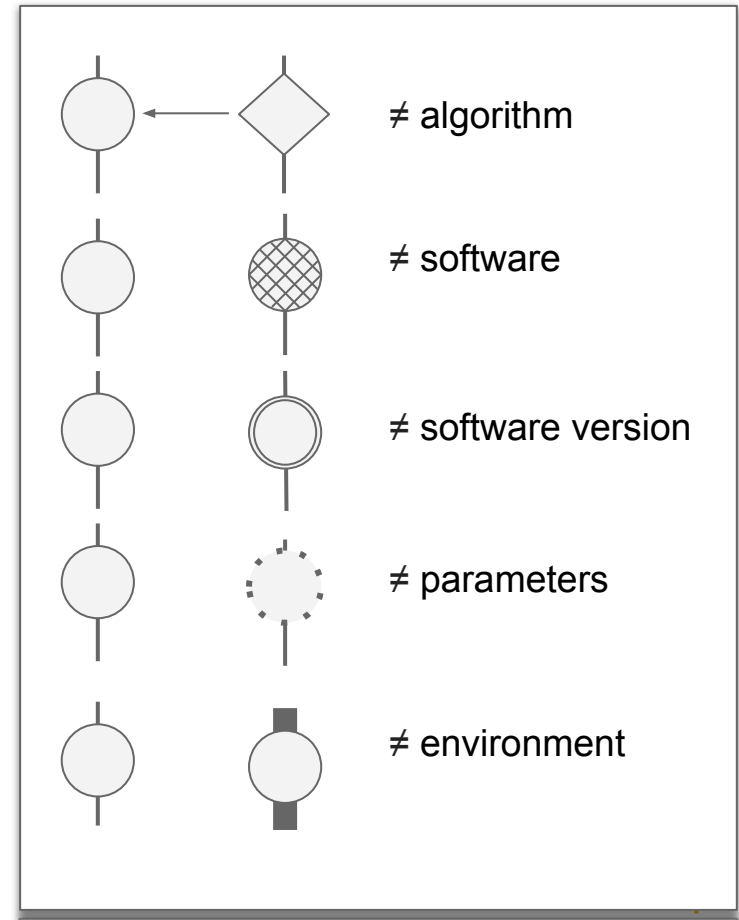
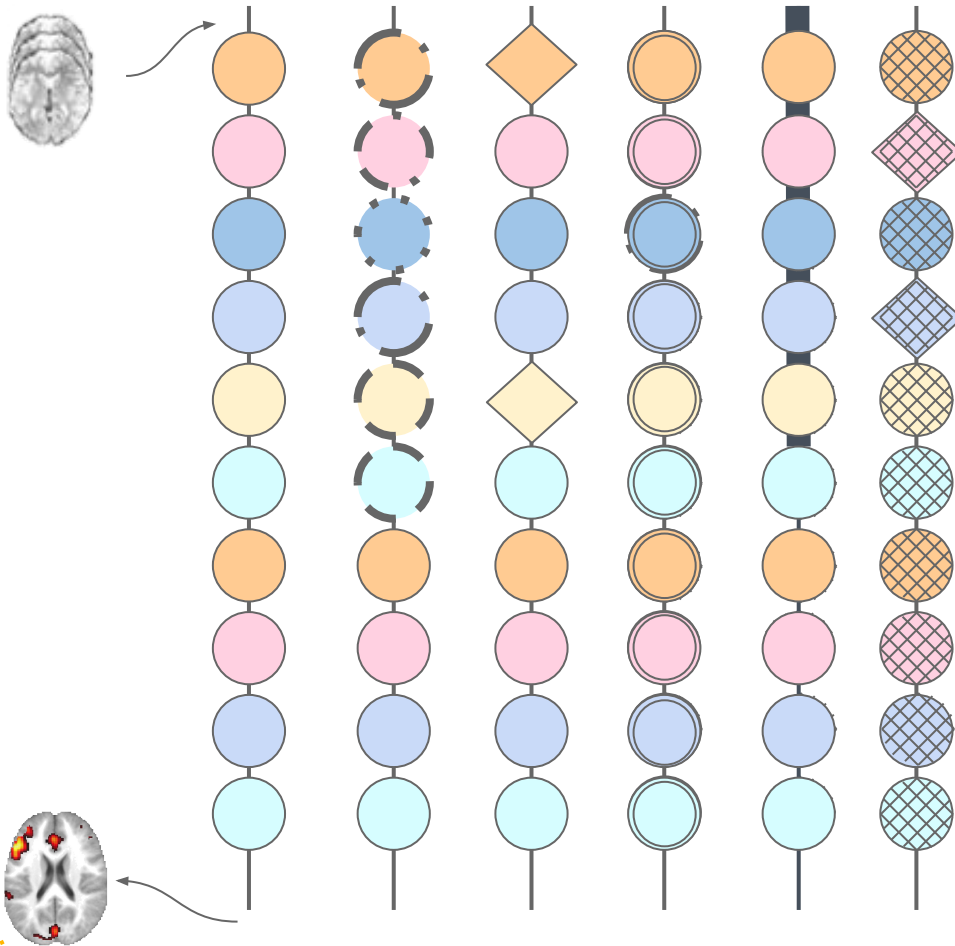
Types of analytical variations



Types of analytical variations



Types of analytical variations



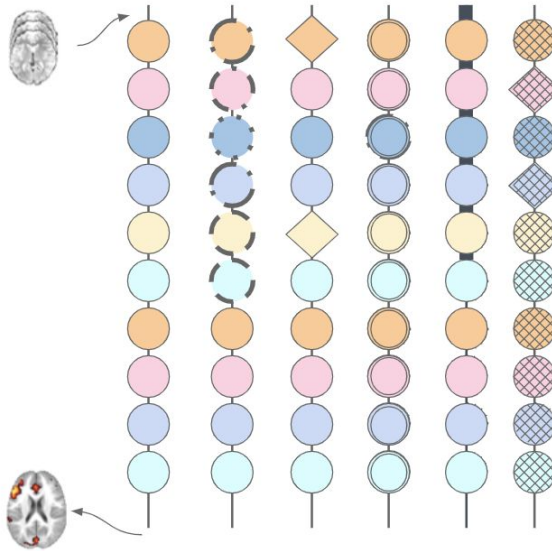
Can we explain this
analytical variability?

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...

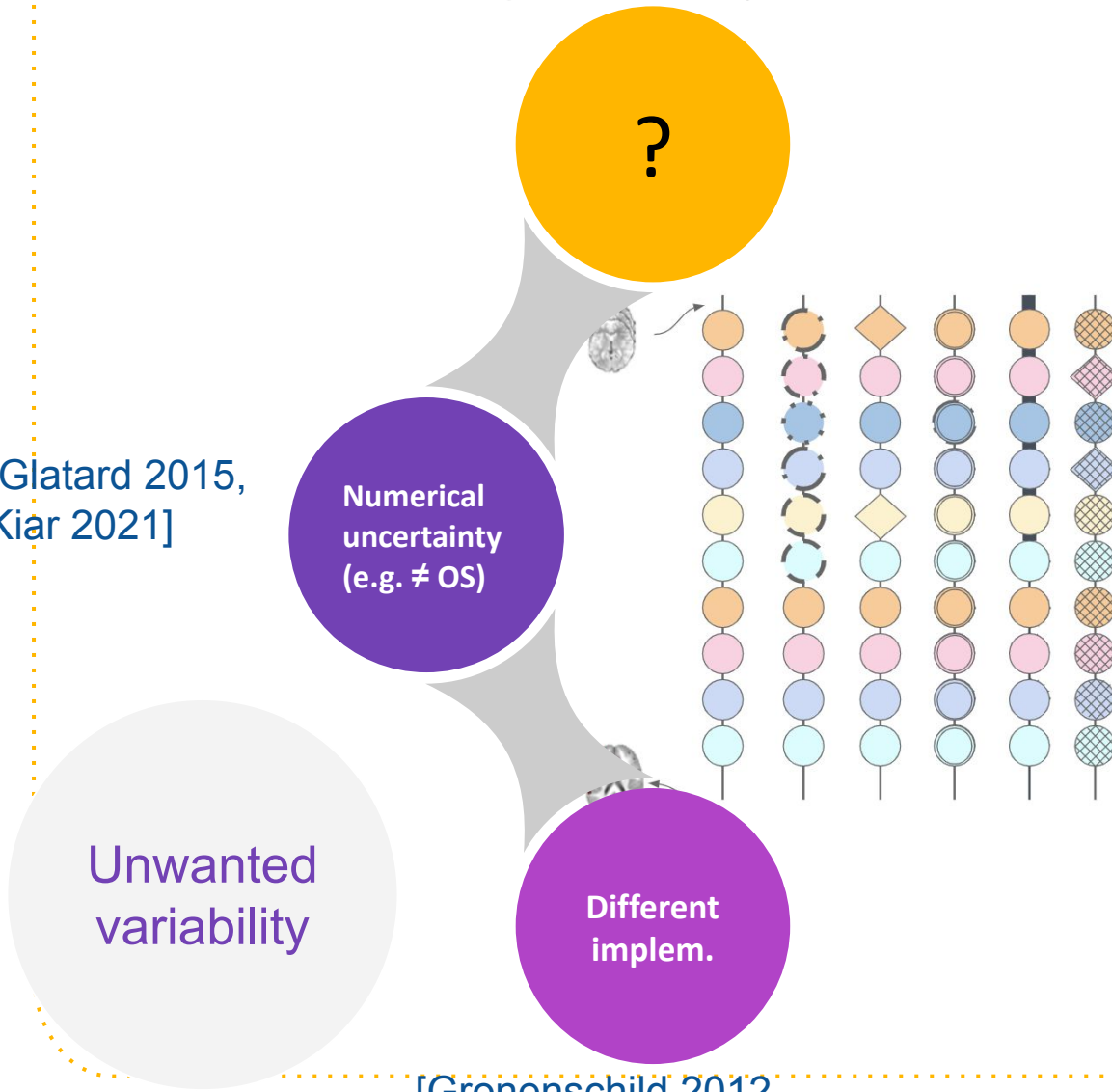
[Glatard 2015,
Kiar 2021]

Numerical
uncertainty
(e.g. \neq OS)

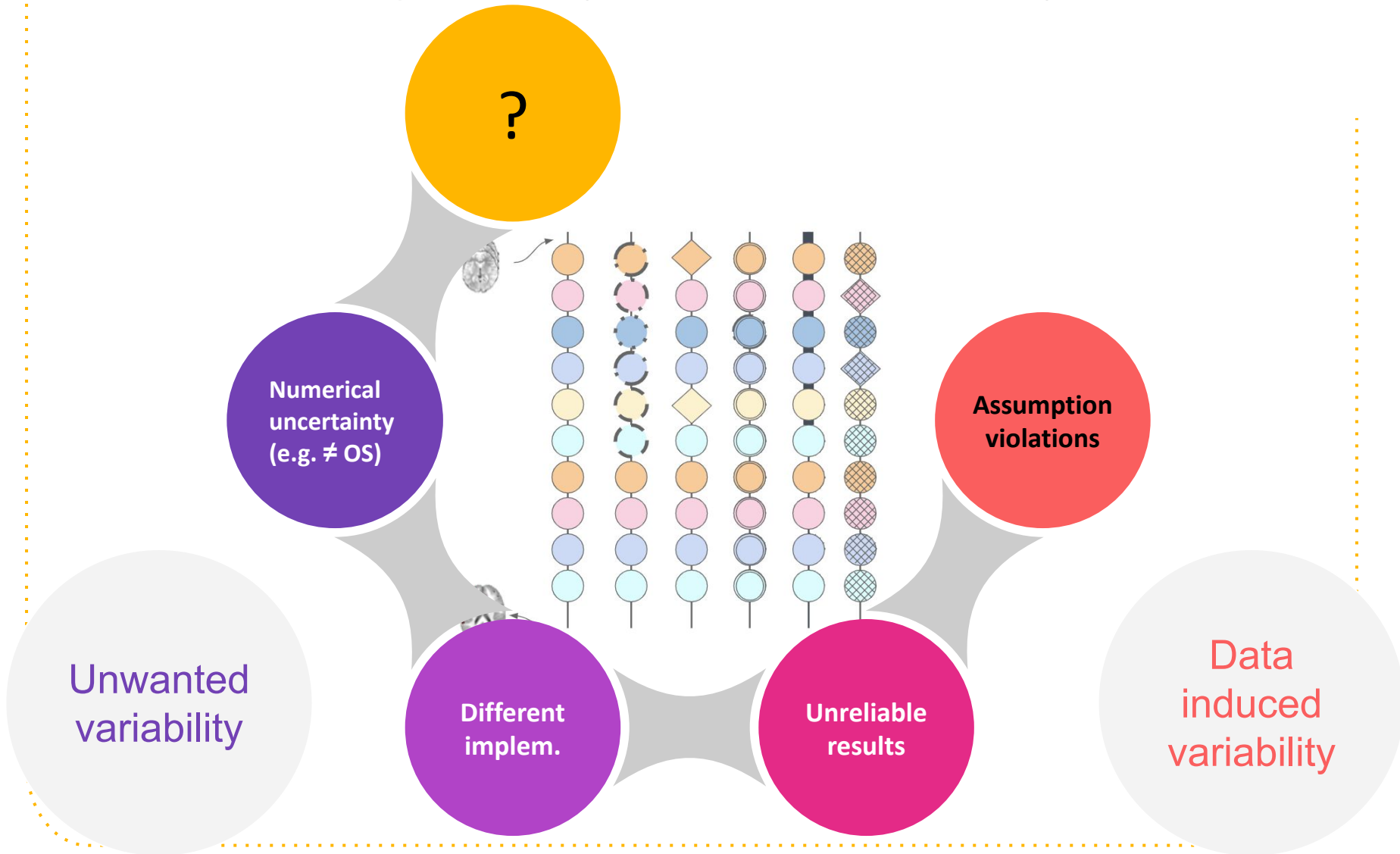
Unwanted
variability

Different
implem.

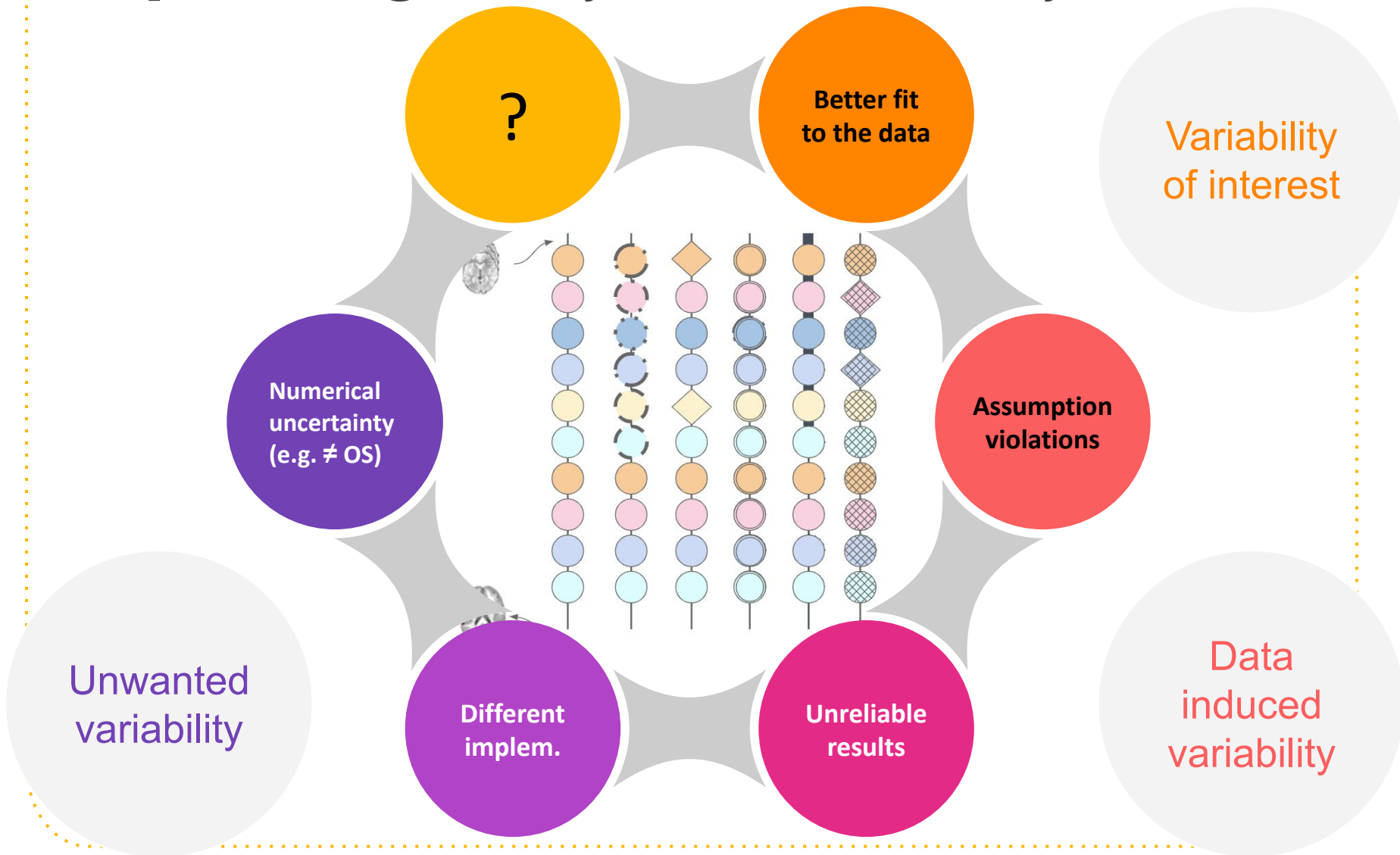
[Gronenschild 2012,
Bowring 2019]



Explaining analytical variability...



Explaining analytical variability...

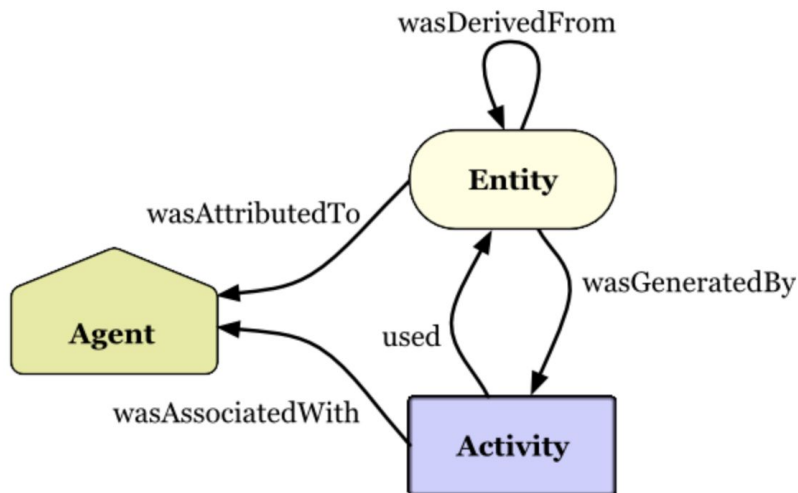


How can **recording
provenance** help
manage analytical
variability?

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?

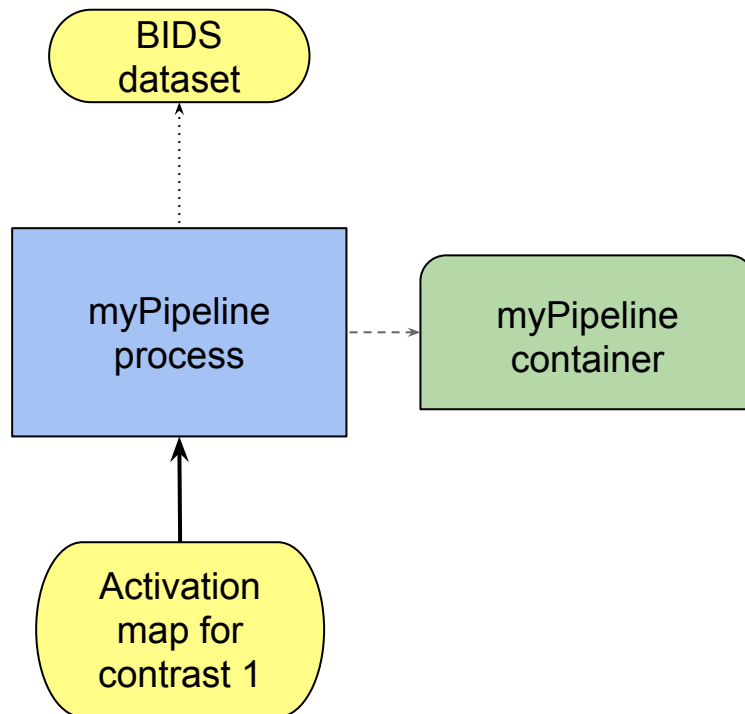
Which registration algorithm was selected?

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

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

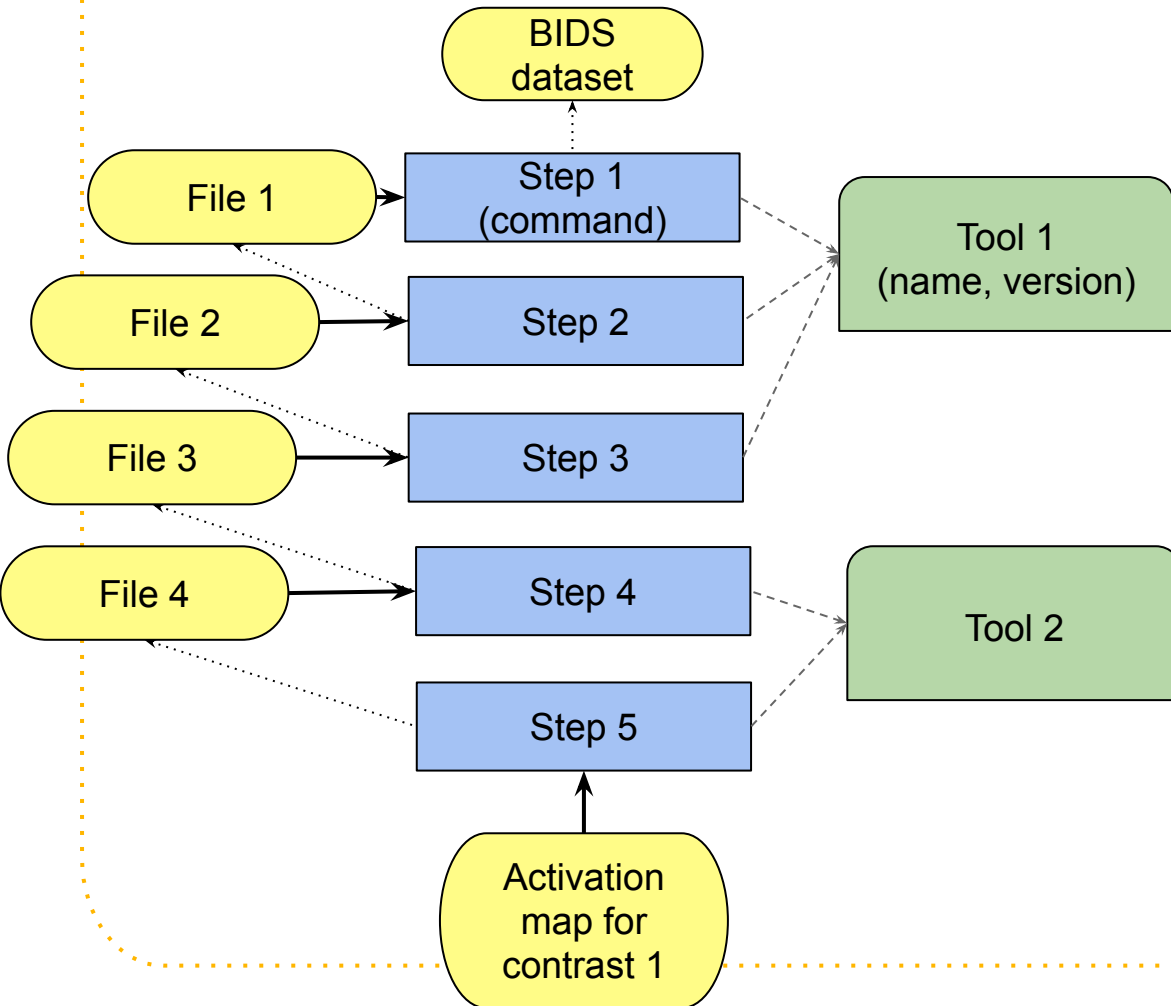
A previously
widely-used
**parameter is no
longer considered
as best practice**

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?

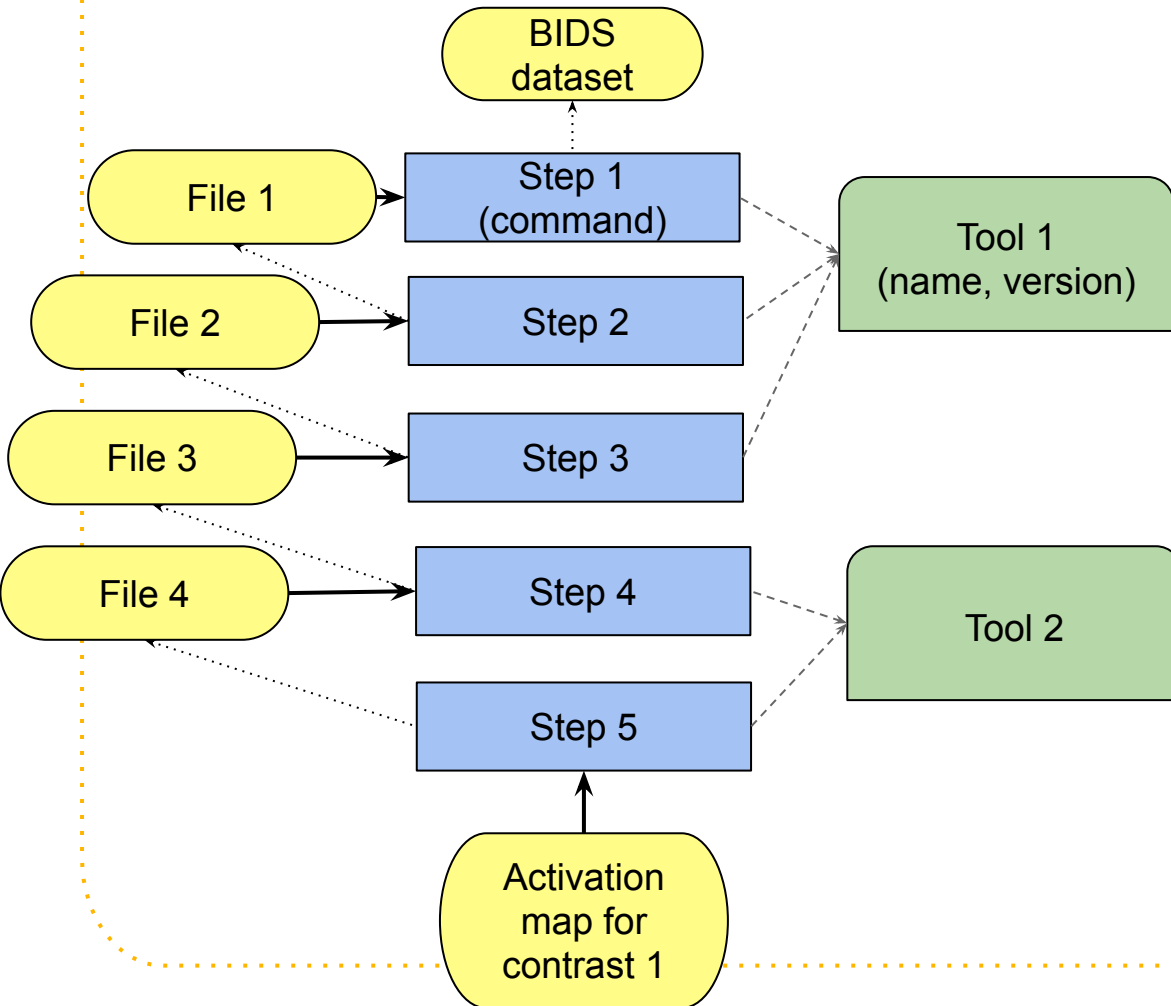
Provenance Use Case 2 **Dealing with unwanted variability**



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?

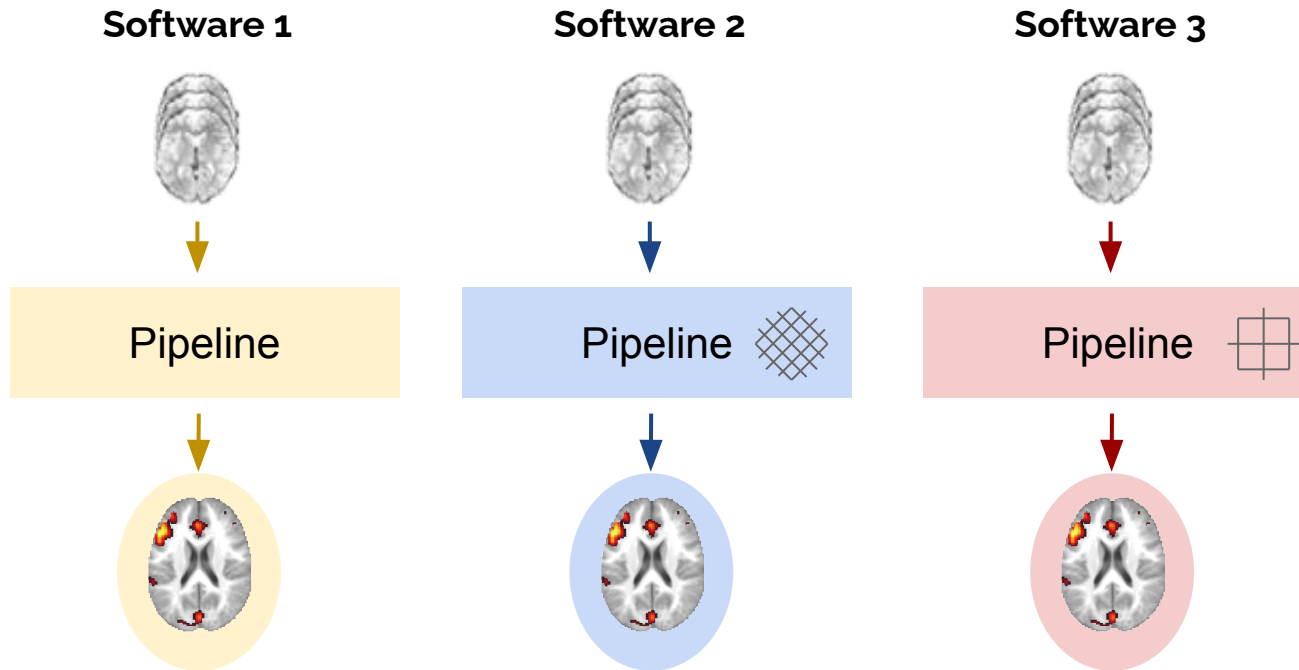
Provenance Use Case 3 **Exploring factors
impacting analytical variability**

Variability across software

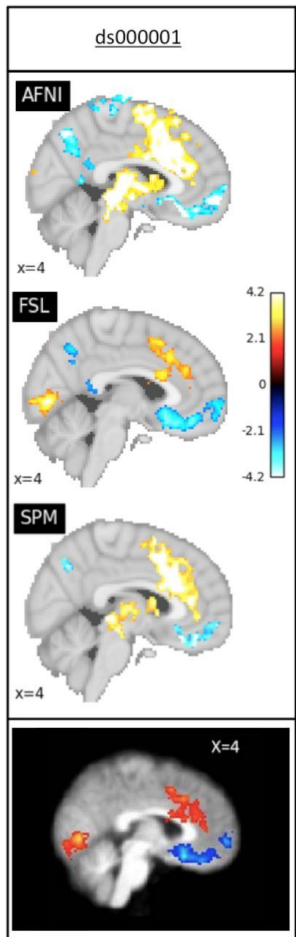
- Reproduced 3 published functional MRI studies
- Using 3 different neuroimaging software packages



Alex Bowring Tom Nichols



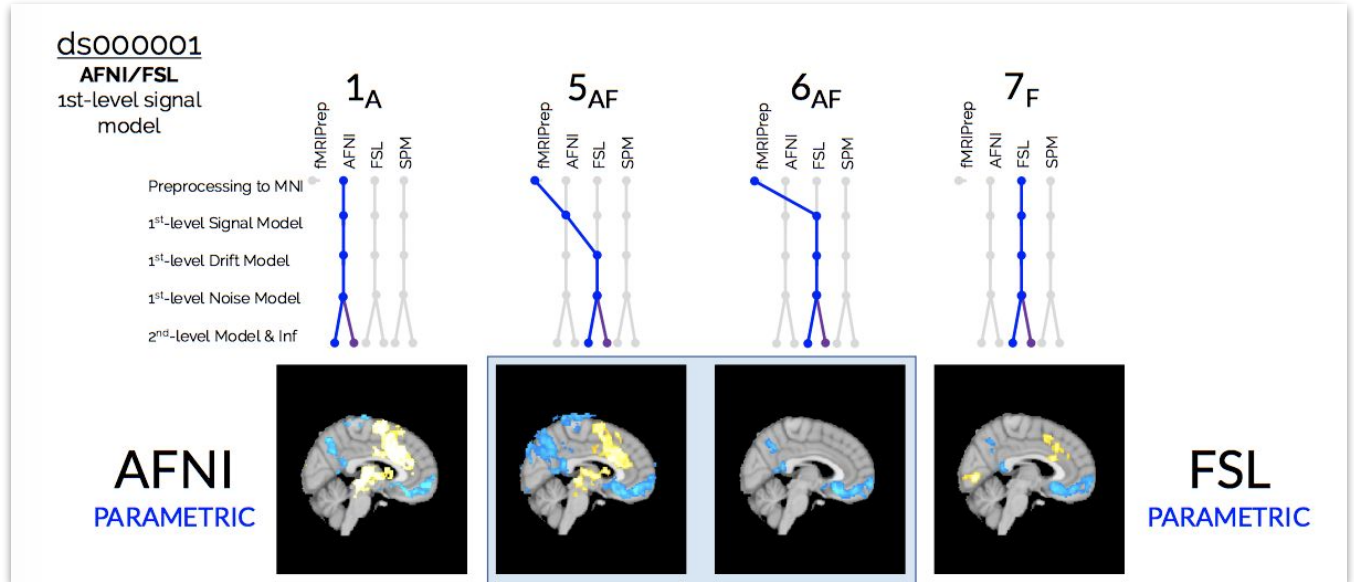
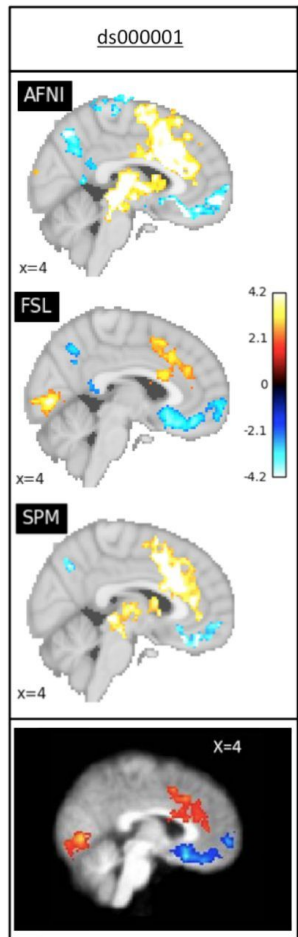
Variability across software



Thresholded maps in AFNI,
FSL, SPM + original

[Bowring et. al, HBM 2019]

Variability across software



[Bowring et. al, HBM 2021]

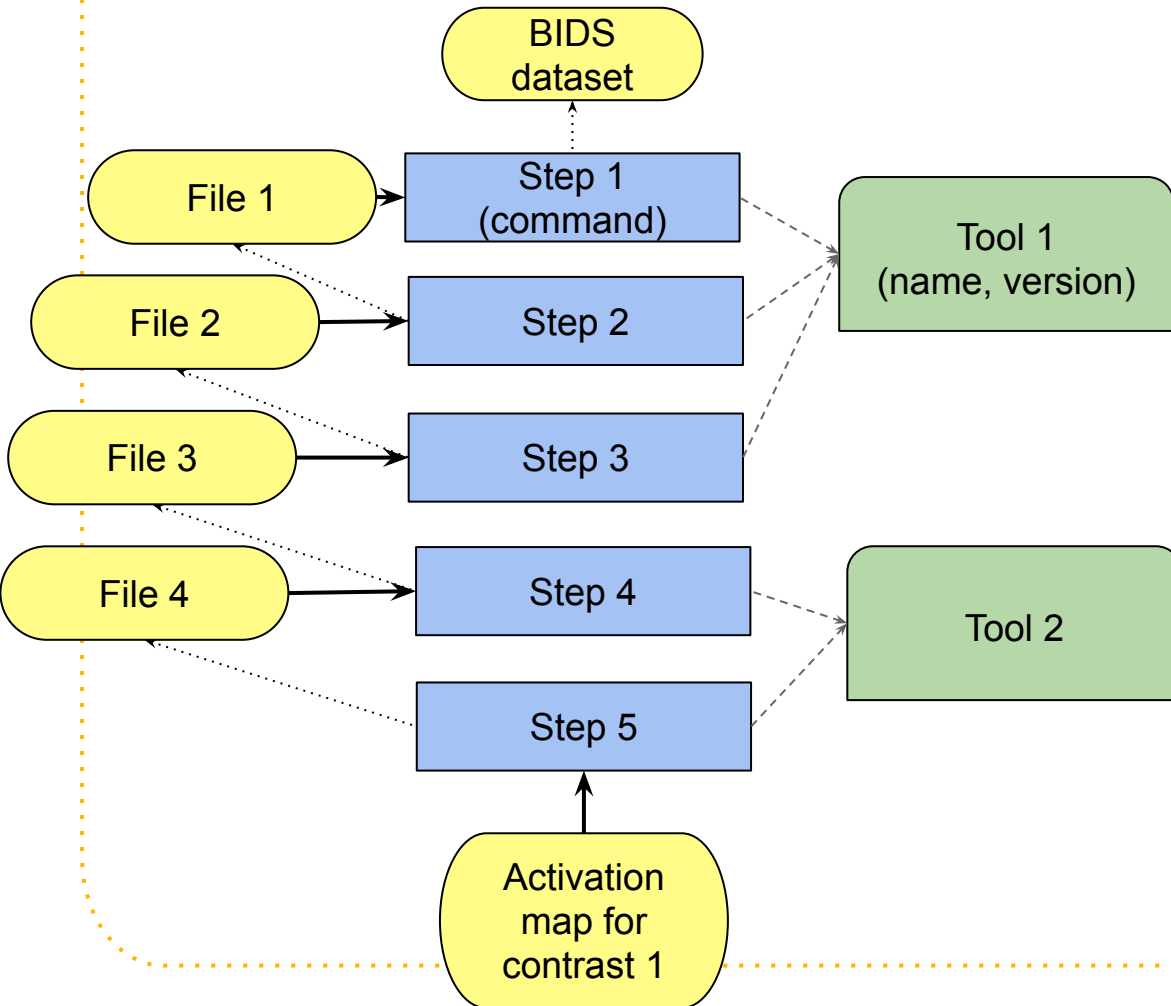
Thresholded maps in AFNI,
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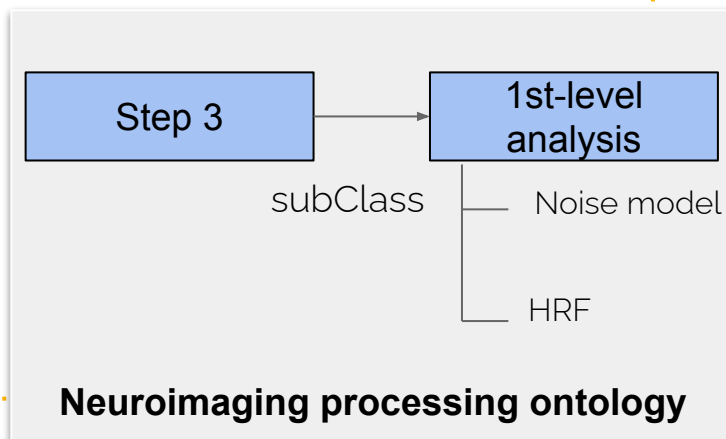
Provenance Use Case 3 **Exploring factors impacting analytical variability**

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

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?



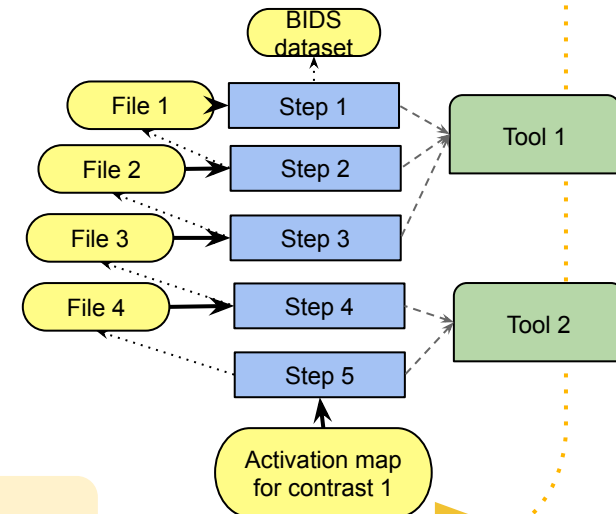
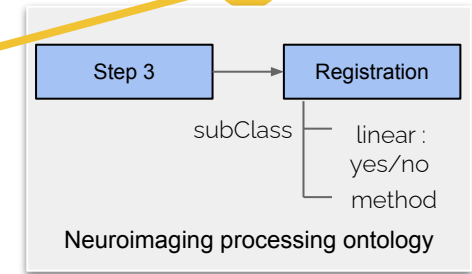
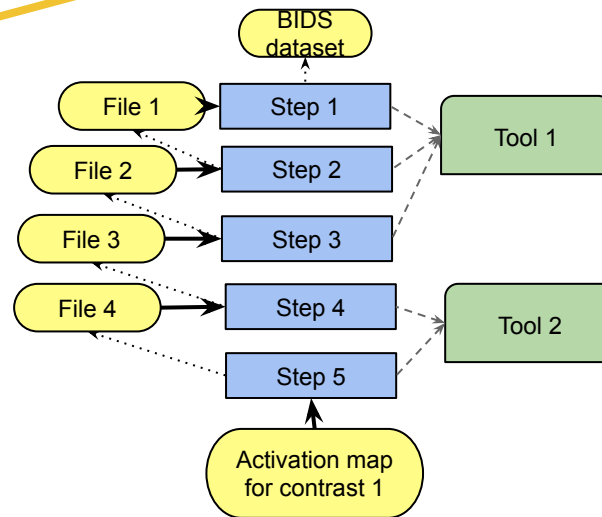
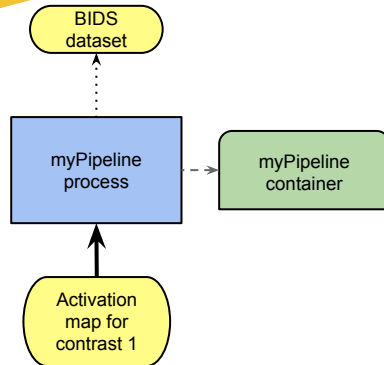
Neuroimaging processing ontology

Recording provenance to help manage analytical variability

Step-level + ontology

Pipeline-level

Step-level



+ Complex / Rich
+ Use cases

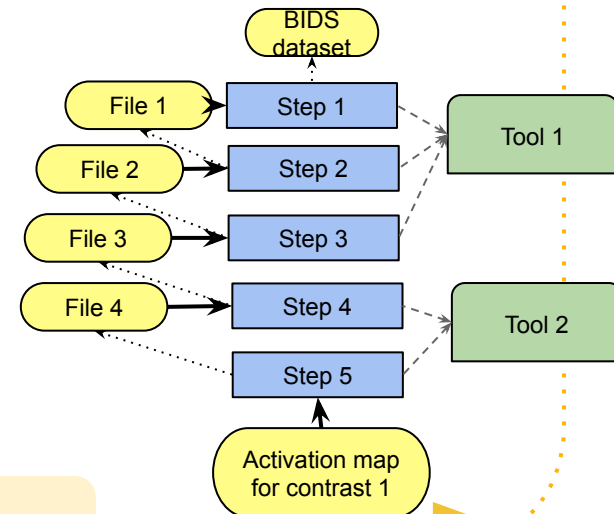
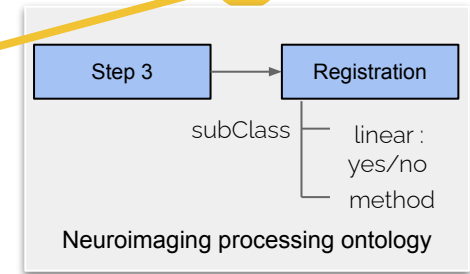
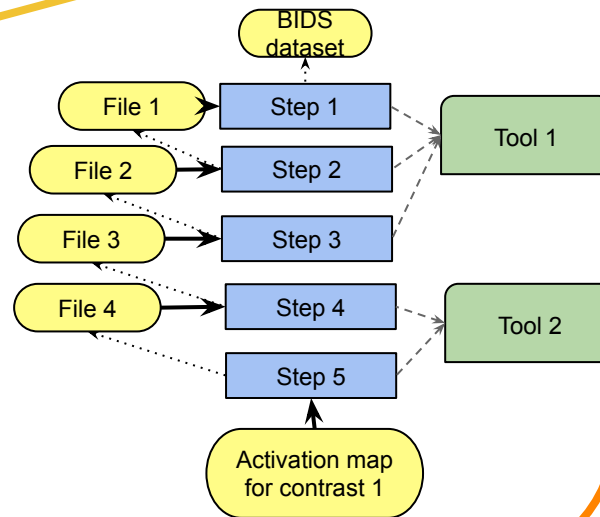
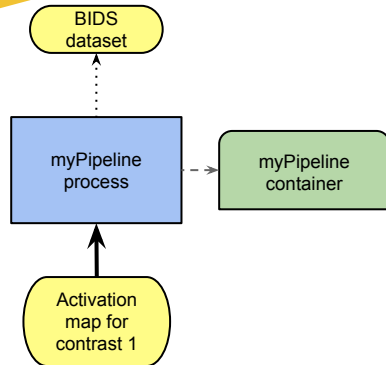
Recording provenance to help manage analytical variability

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

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

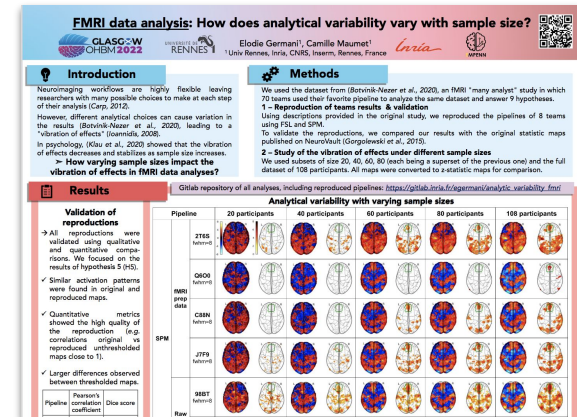
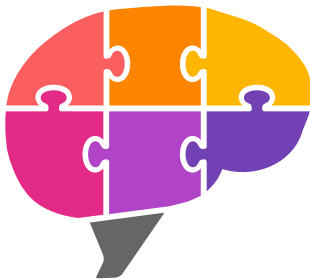
Components and records of provenance

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

Thank you!



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