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## Different analysis pipelines, different results... How to deal with analytical variability?

Camille Maumet

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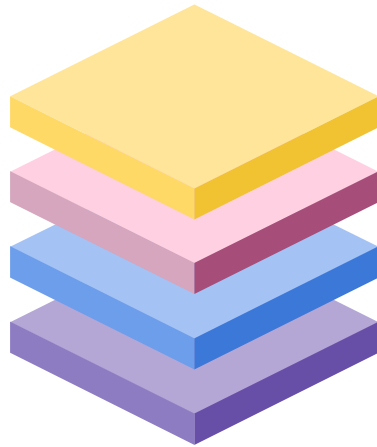
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*Special session* 10 years of reproducibility in biomedical research: how can we achieve generalizability and fairness?



# Different analysis pipelines, different results...

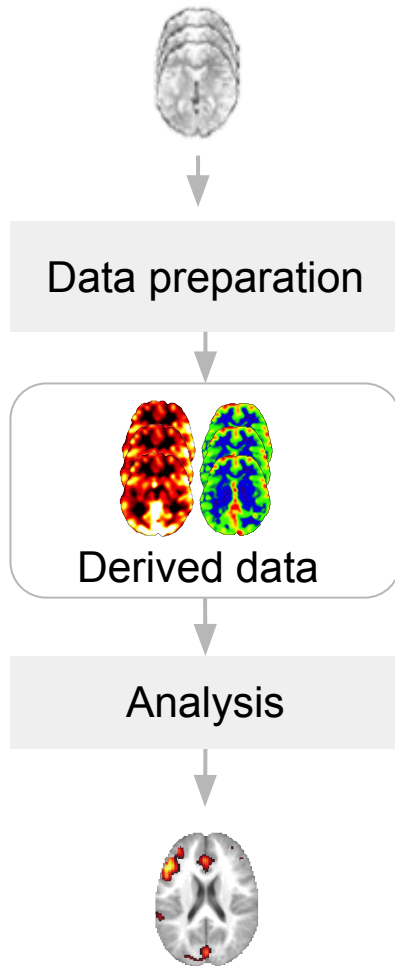
How to deal with analytical variability?

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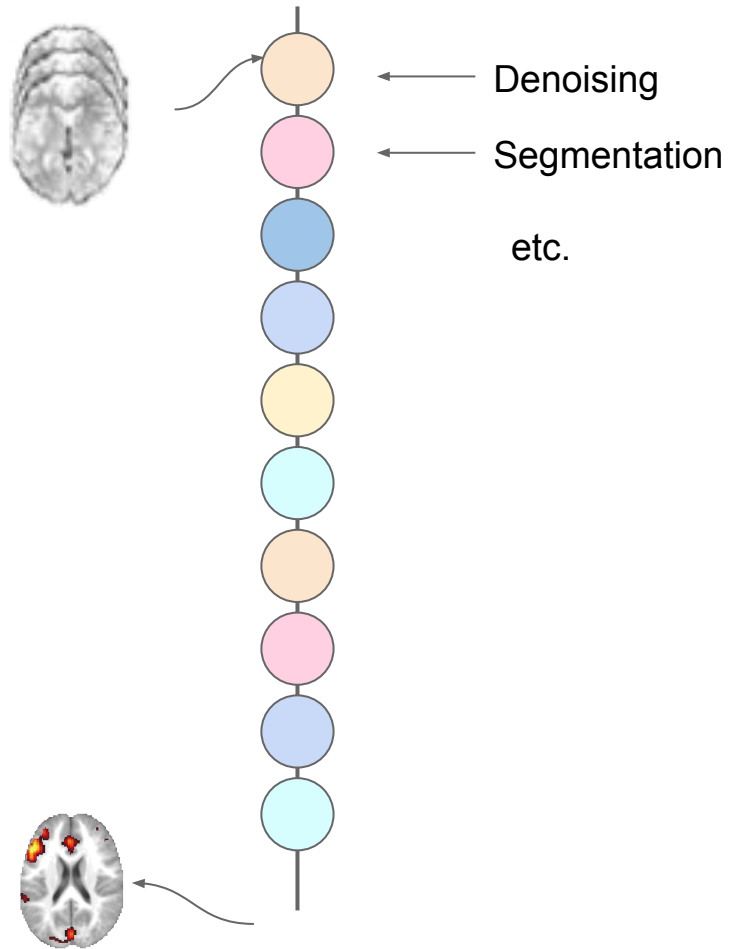
Inria, Univ Rennes, Inserm, CNRS, IRISA



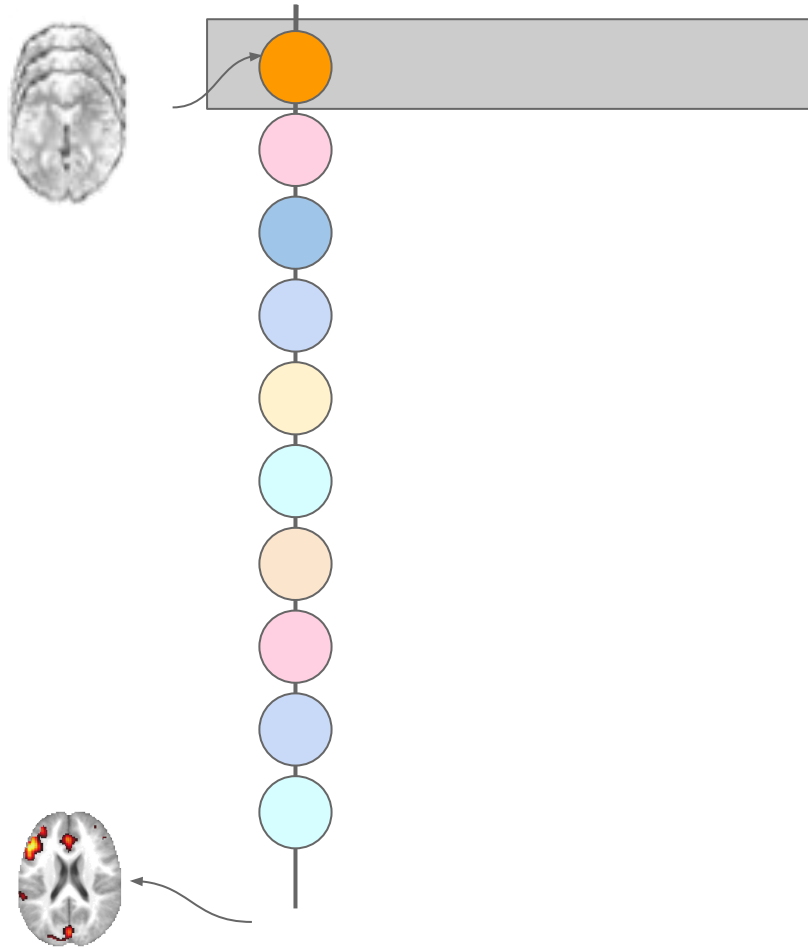
# Analytical pipelines



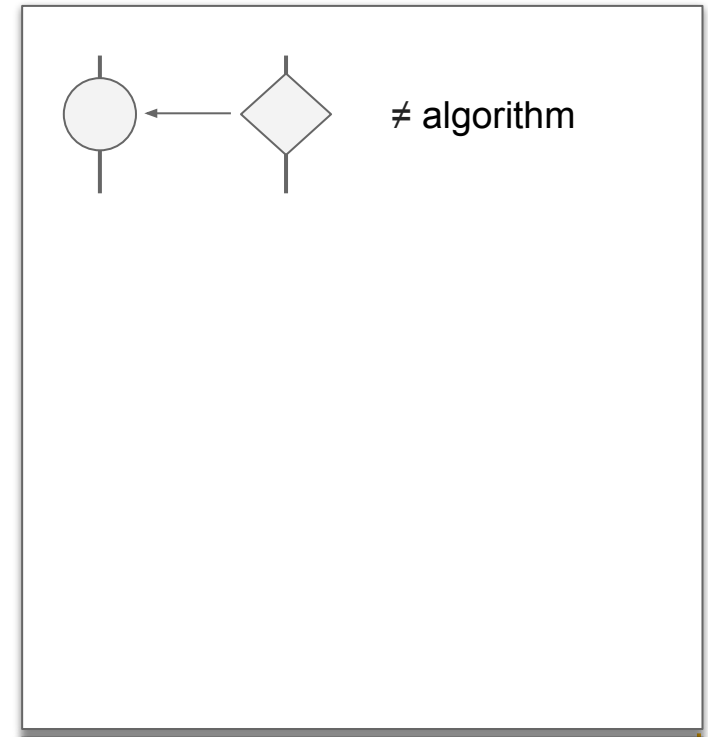
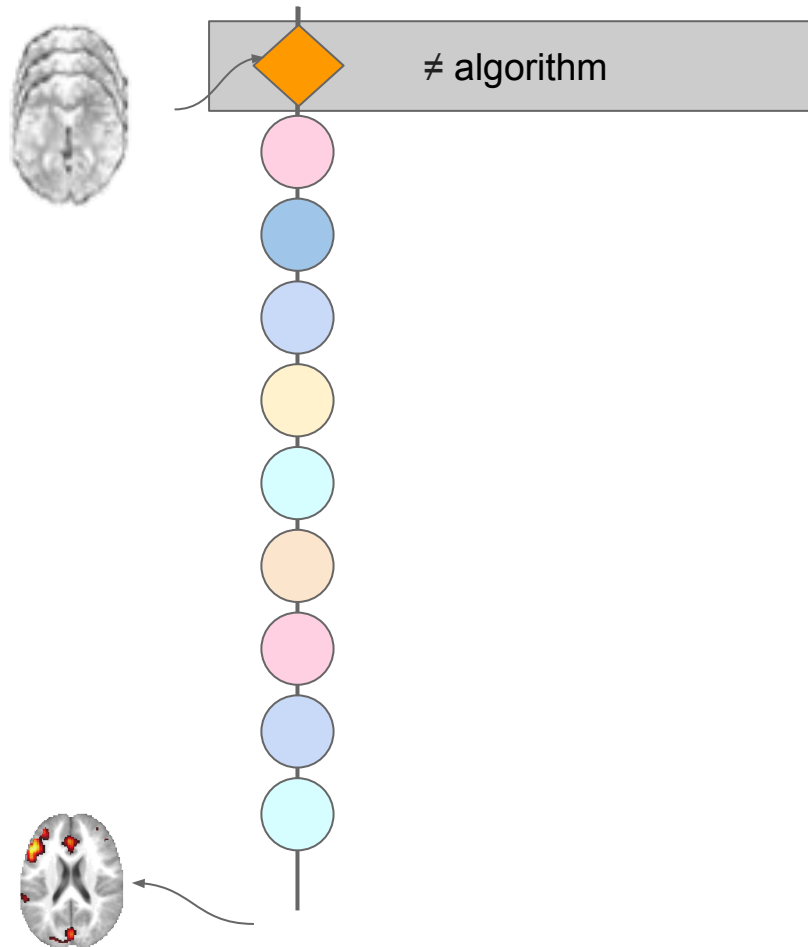
# Analytical pipelines



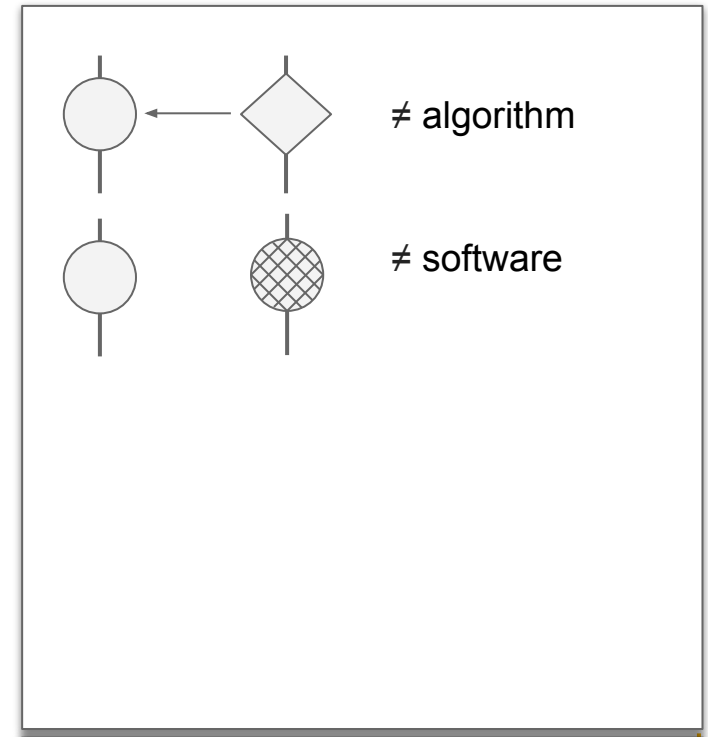
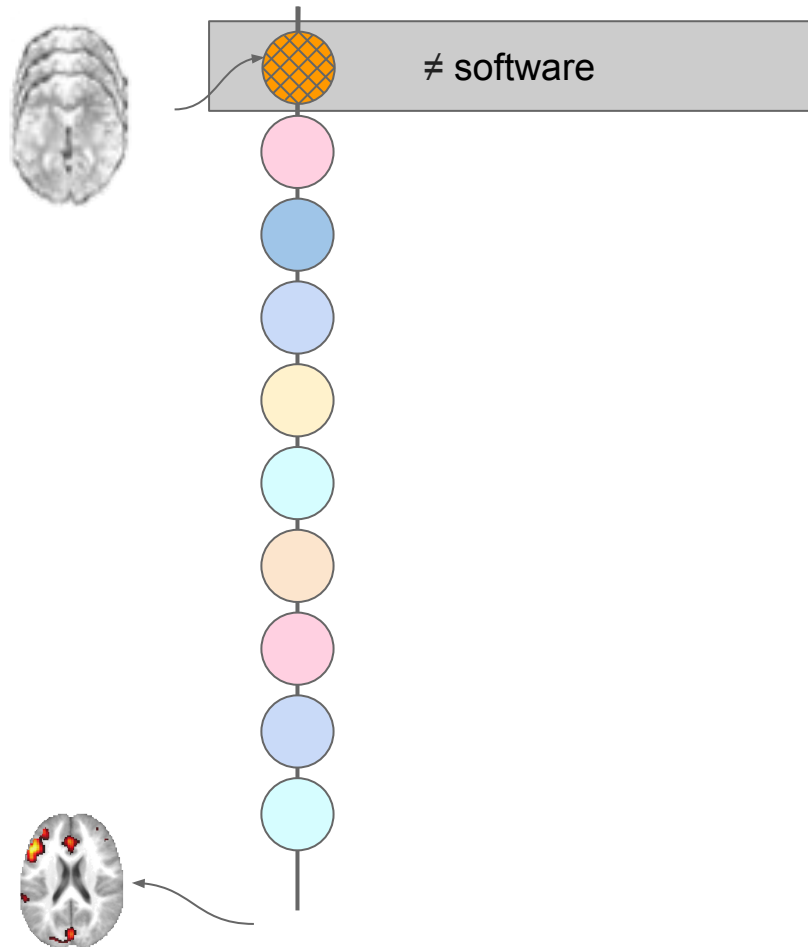
# Analytical pipelines



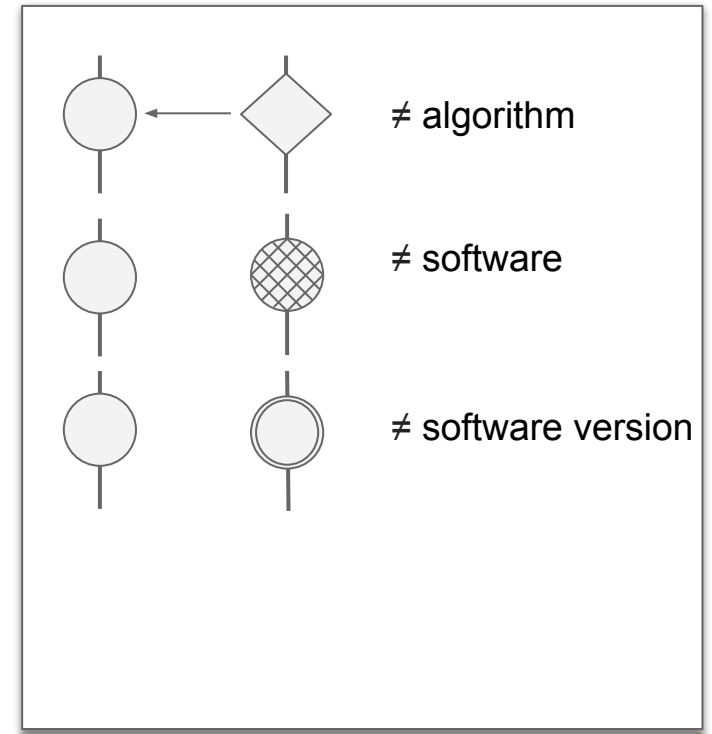
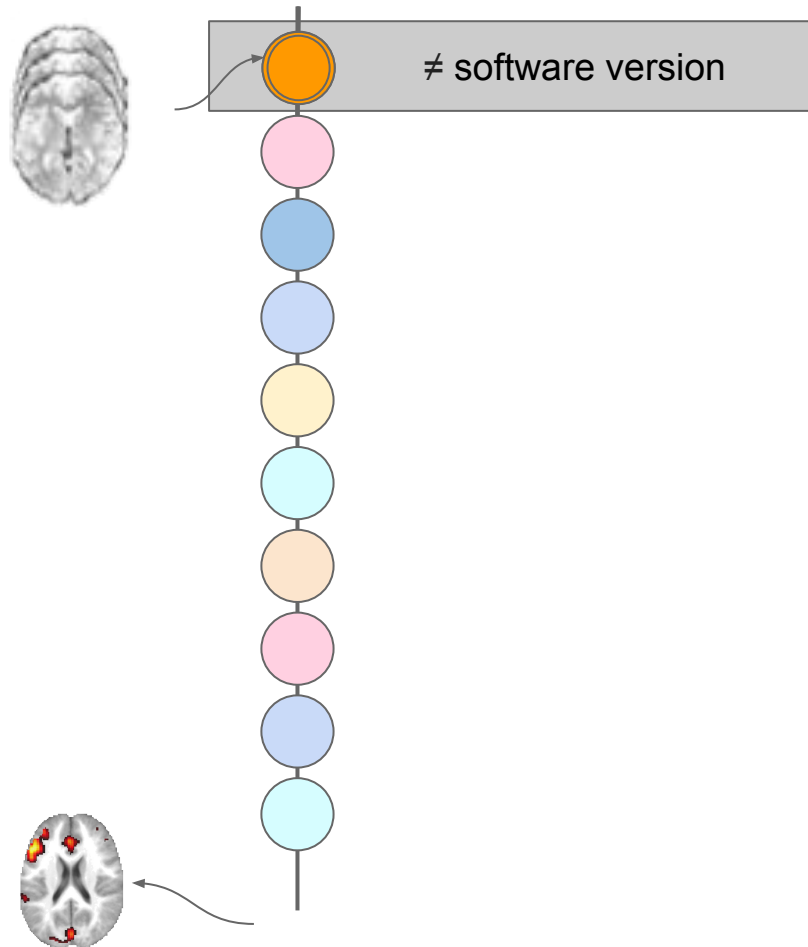
# Analytical pipelines



# Analytical pipelines

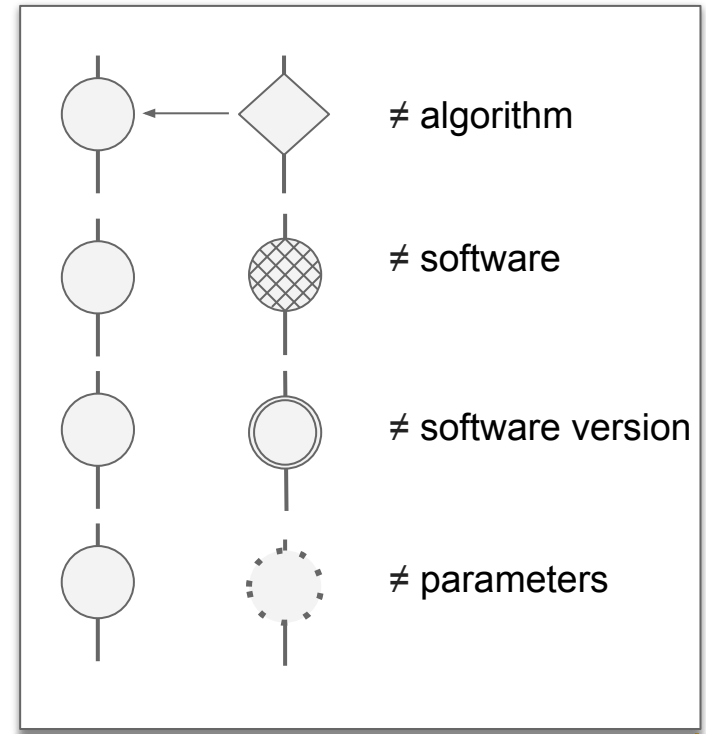
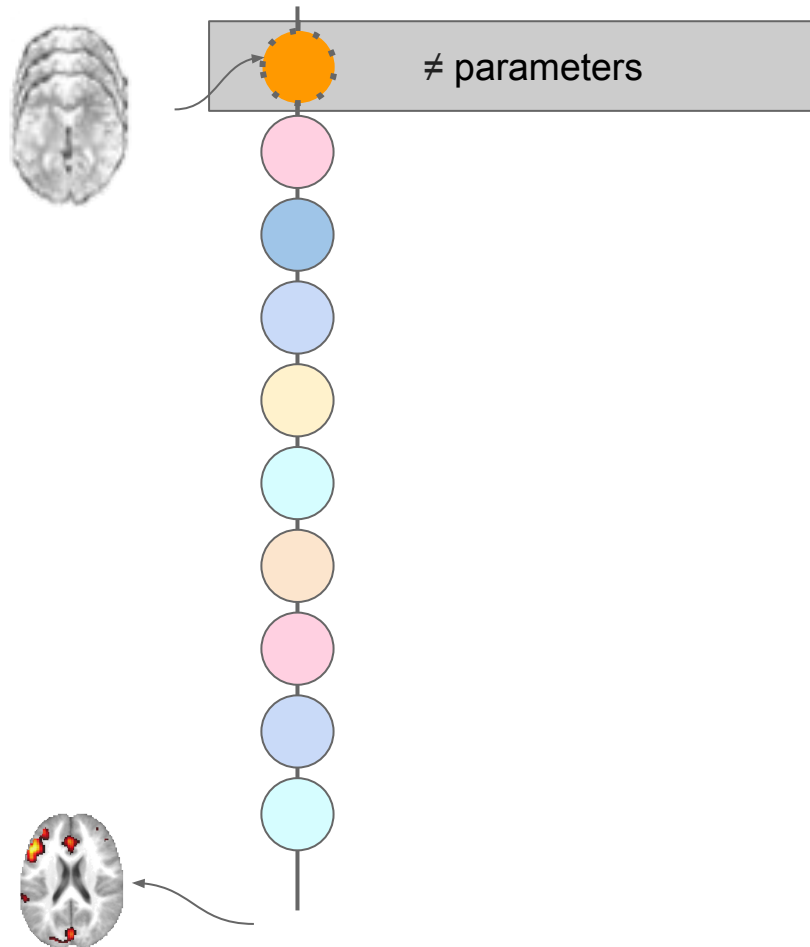


# Analytical pipelines

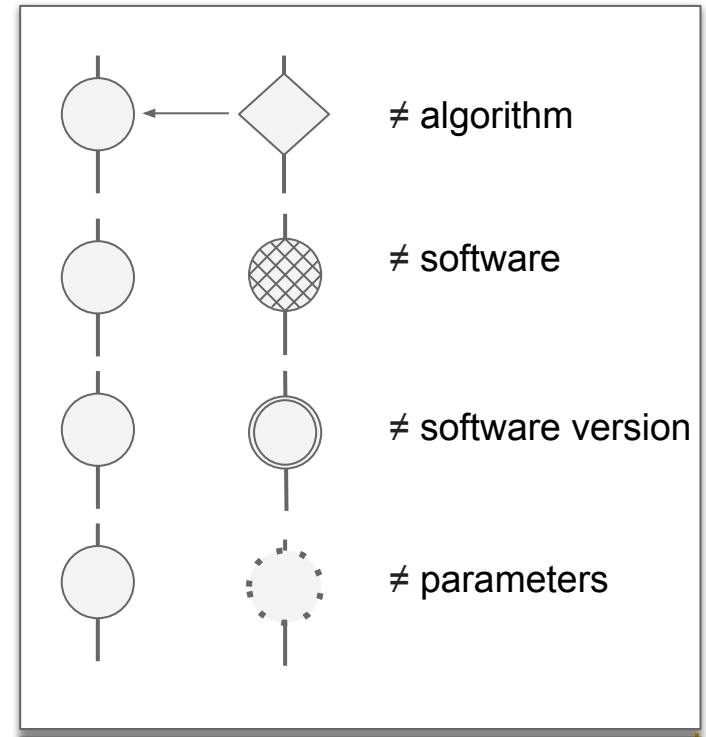
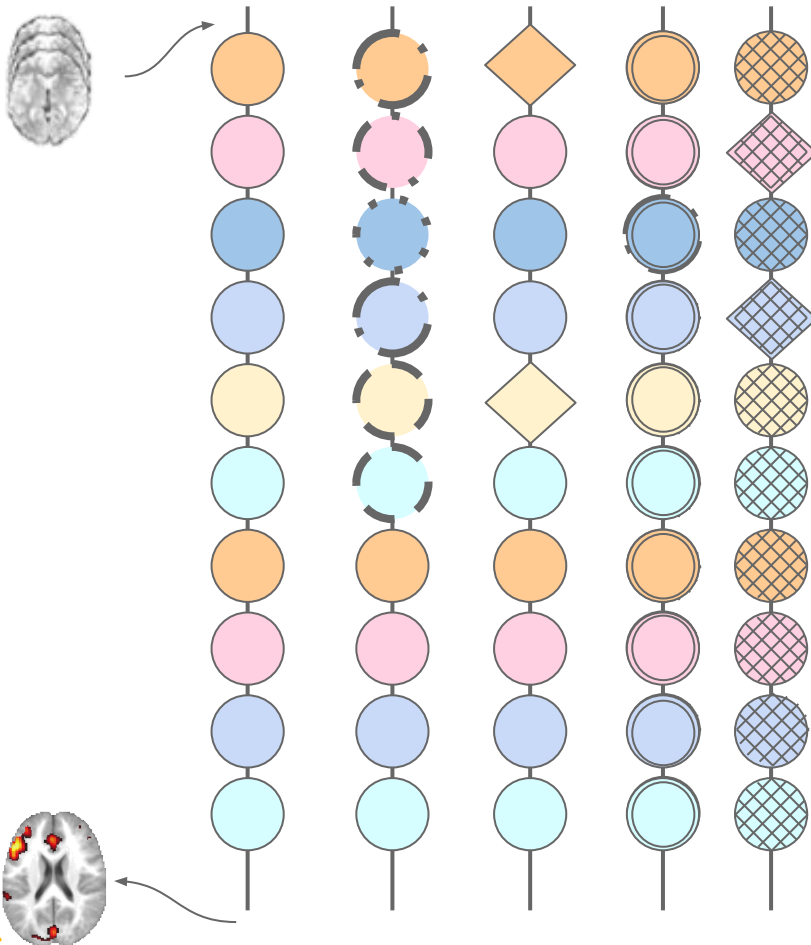




# Analytical pipelines

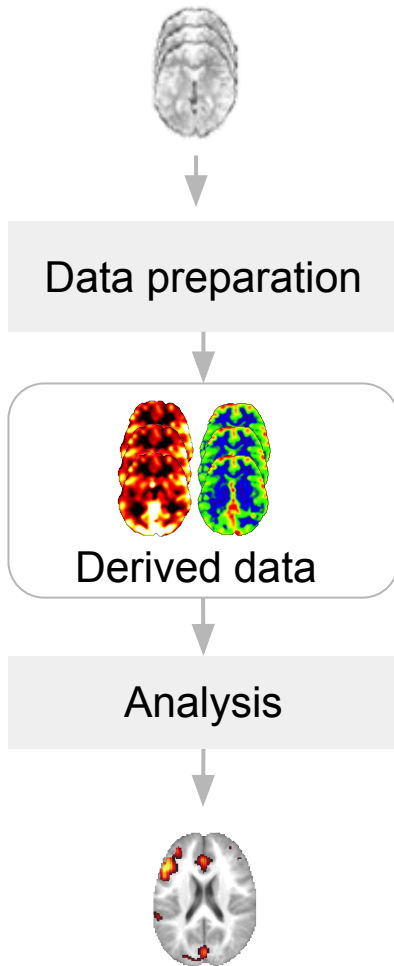


# Analytical pipelines

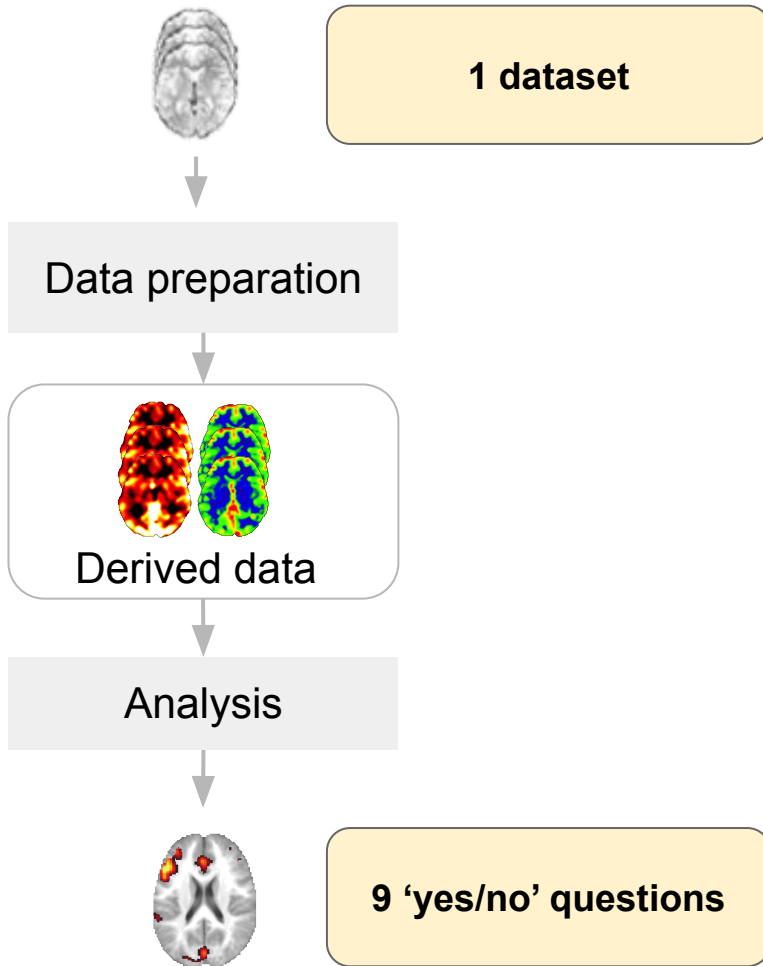


A family of "acceptable" pipelines  
over  $10^{30}$  combinations...

# Many analysts project : NARPS

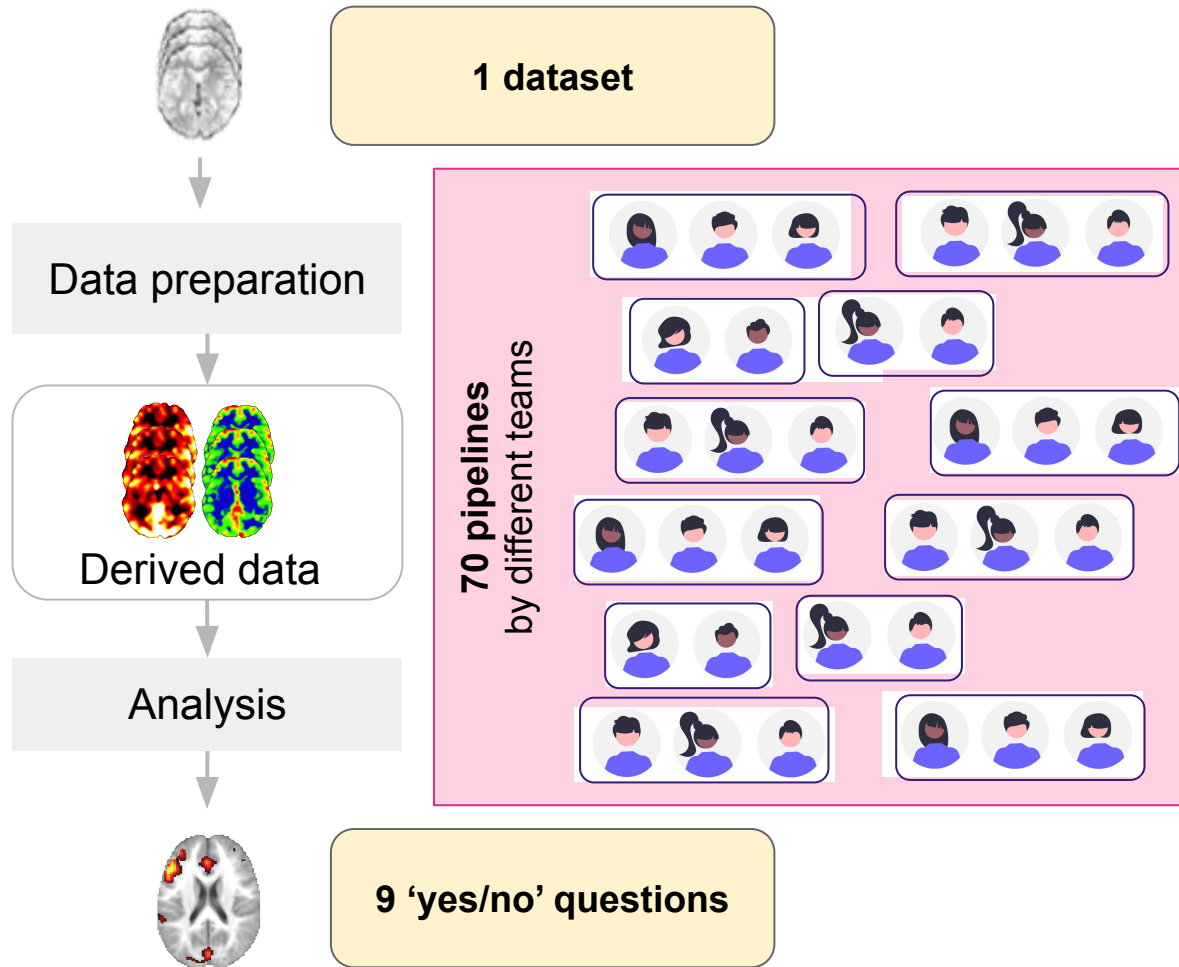


# Many analysts project : NARPS



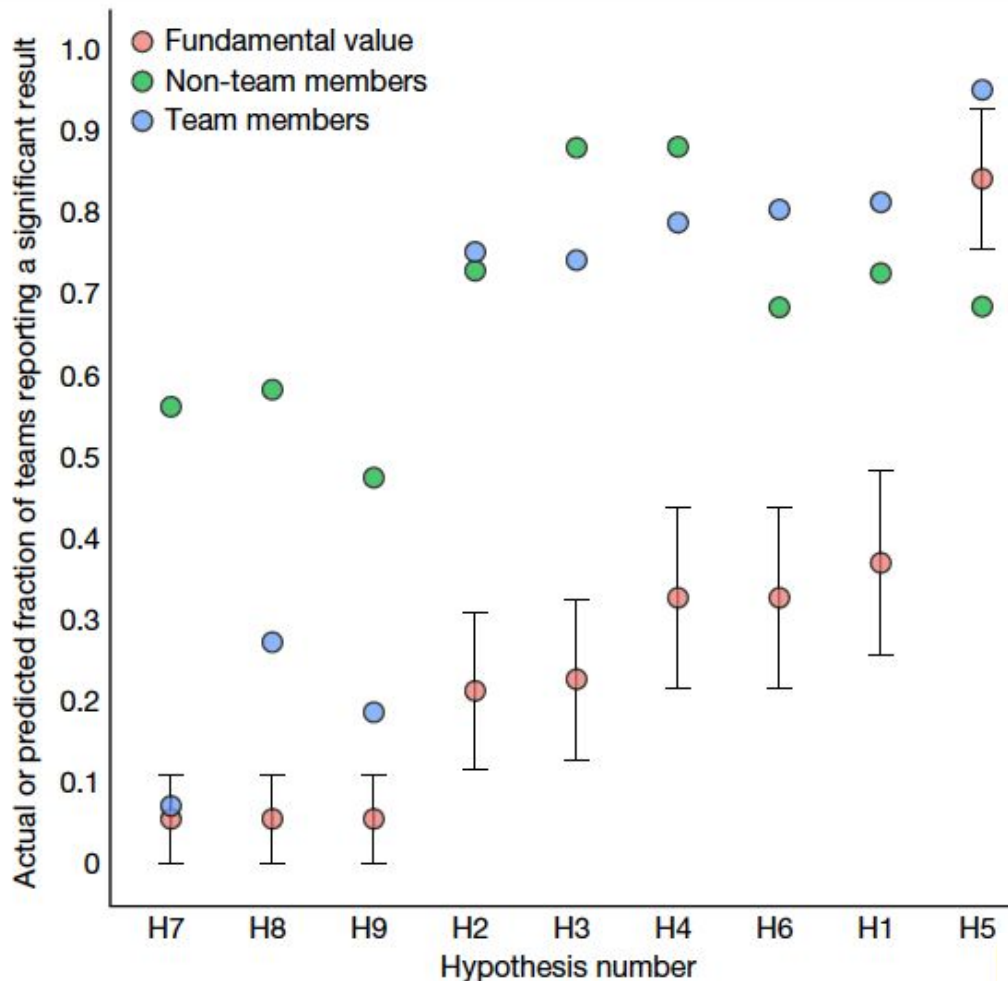
*e.g. Is there a parametric effect of gain:  
Positive effect in ventromedial PFC -  
for the equal indifference group?*

# Many analysts project : NARPS



# Many analysts project : NARPS

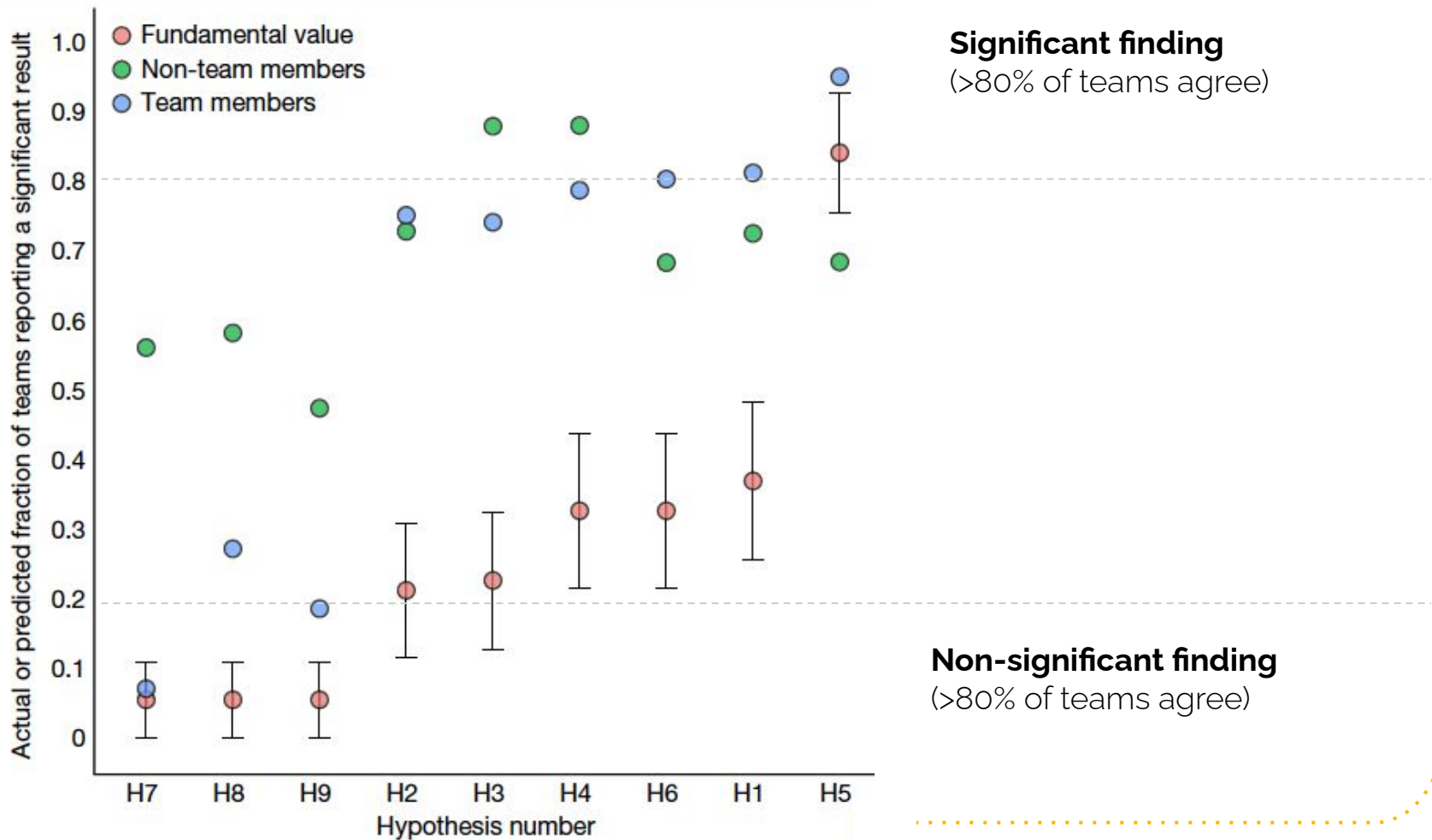
Results over the **70 post-processing pipelines**:



[Botvinik-Nezer et. al, Nature 2020]

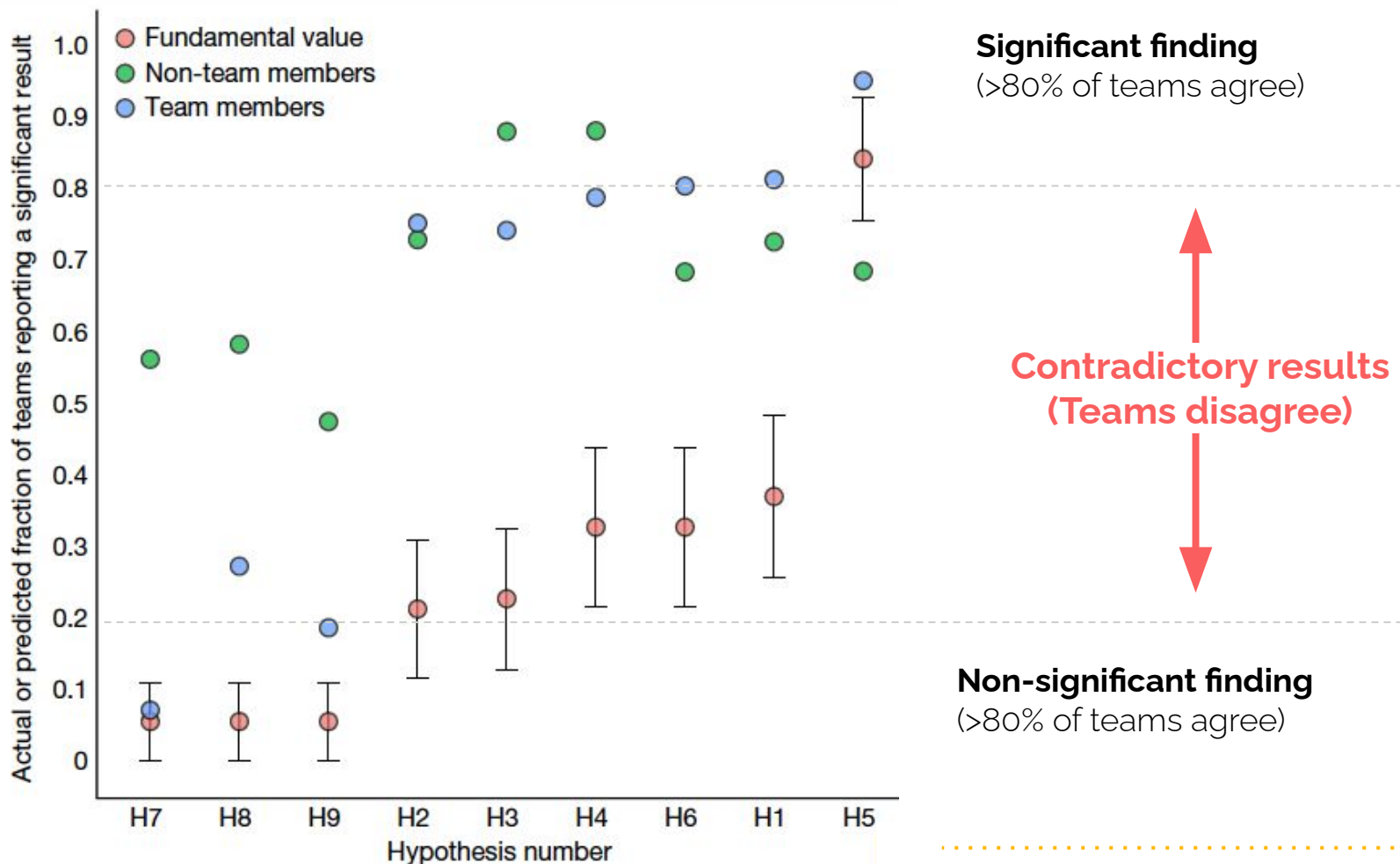
# Many analysts project : NARPS

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



# Many analysts project : NARPS

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





# Different levels of variability in analytical pipelines

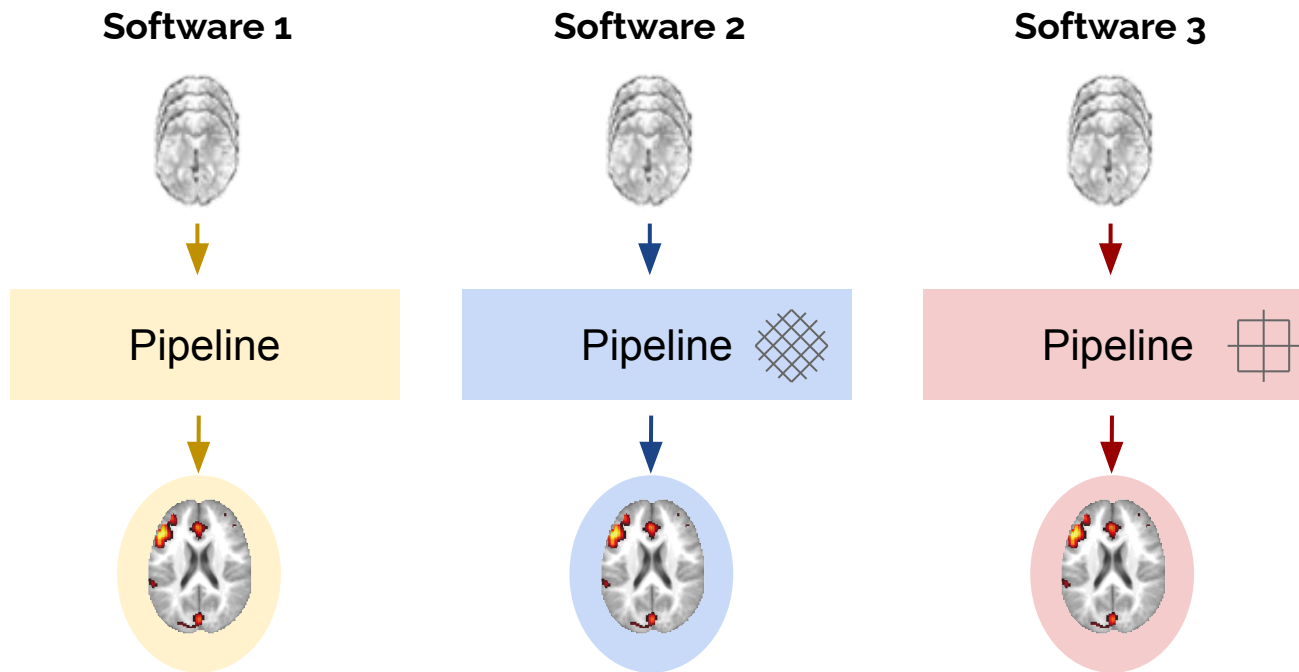
- Different end-to-end pipelines using different algorithms+parameters [Churchill 2012, Carp 2013, Li 2021, Dafflon 2022]
- Different Software Version [Gronenschild 2012]
- Different operating system [Glatard 2015, Kiar 2021]
- Different software packages [Bowring 2019,
- and more...

# Variability across software

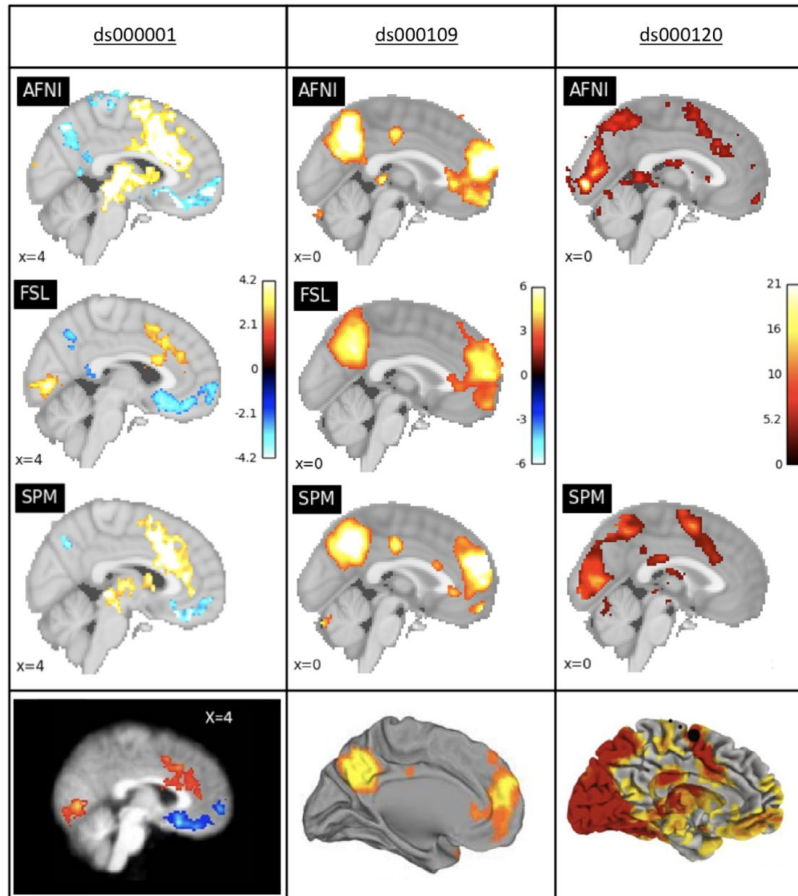
- Reproduced 3 published functional MRI studies
  - ds001, ds109, ds120 (from [Openneuro](#))
- Using 3 different software packages
  - AFNI, FSL, SPM



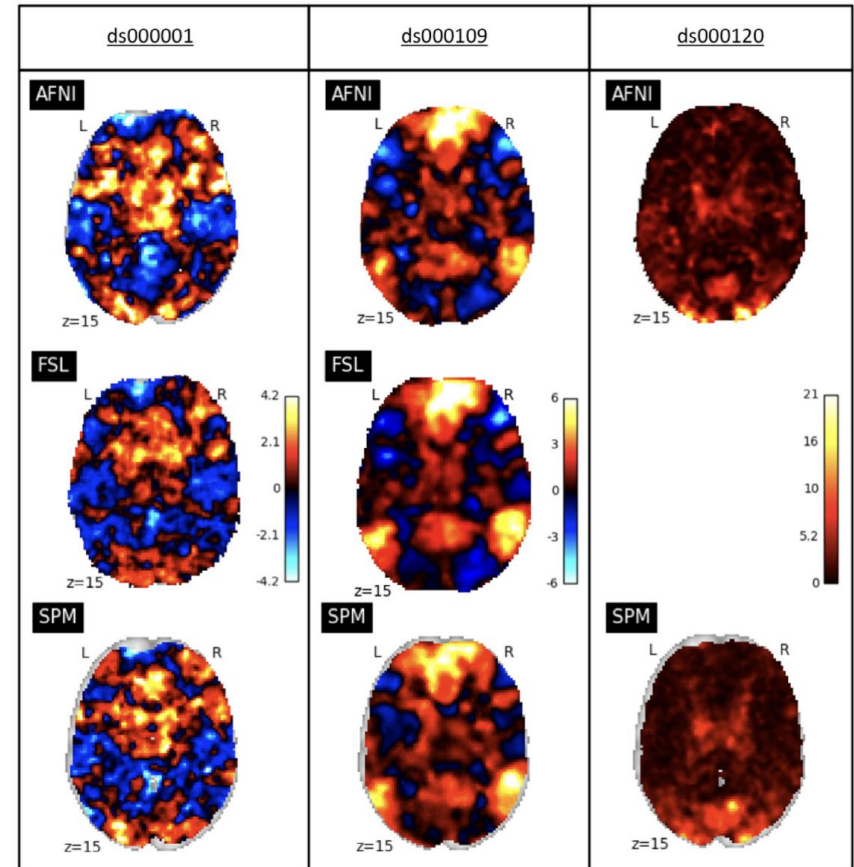
Alex Bowring Tom Nichols



# Software Comparison Project



Comparison of the final results



Comparison of the statistic maps

# **Understanding** analytical variability



# Explaining analytical variability...

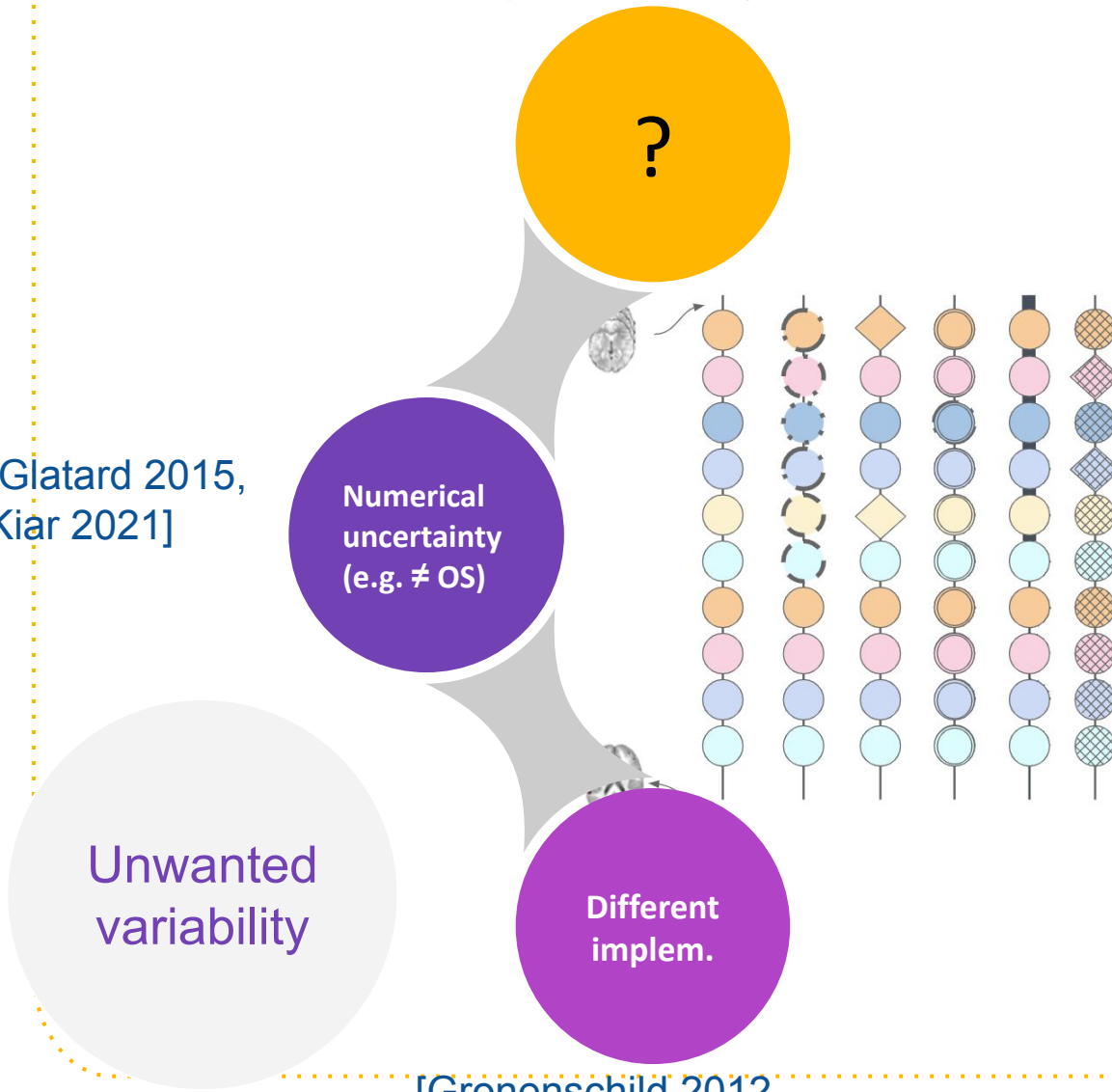
[Glatard 2015,  
Kiar 2021]

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

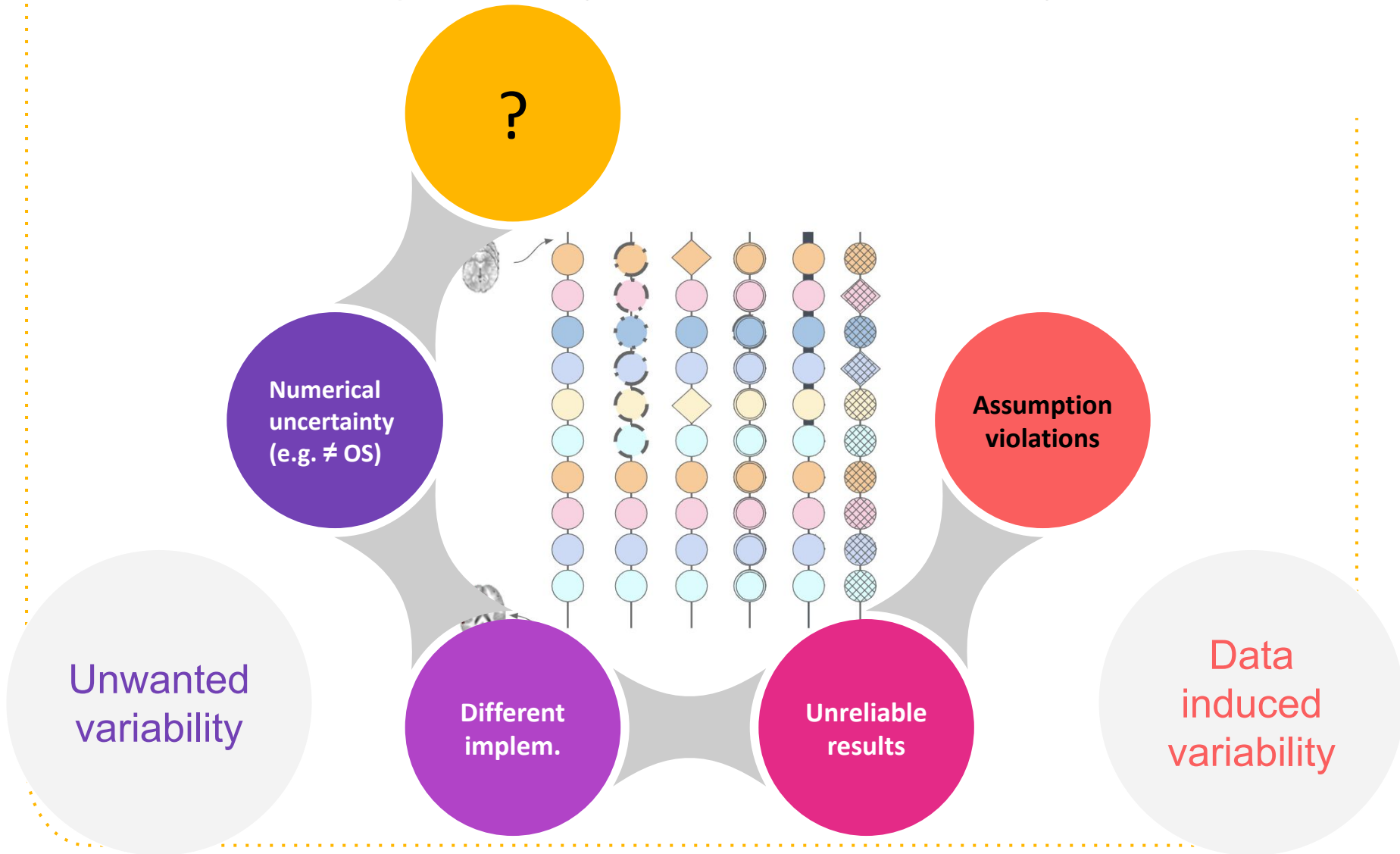
Unwanted  
variability

Different  
implem.

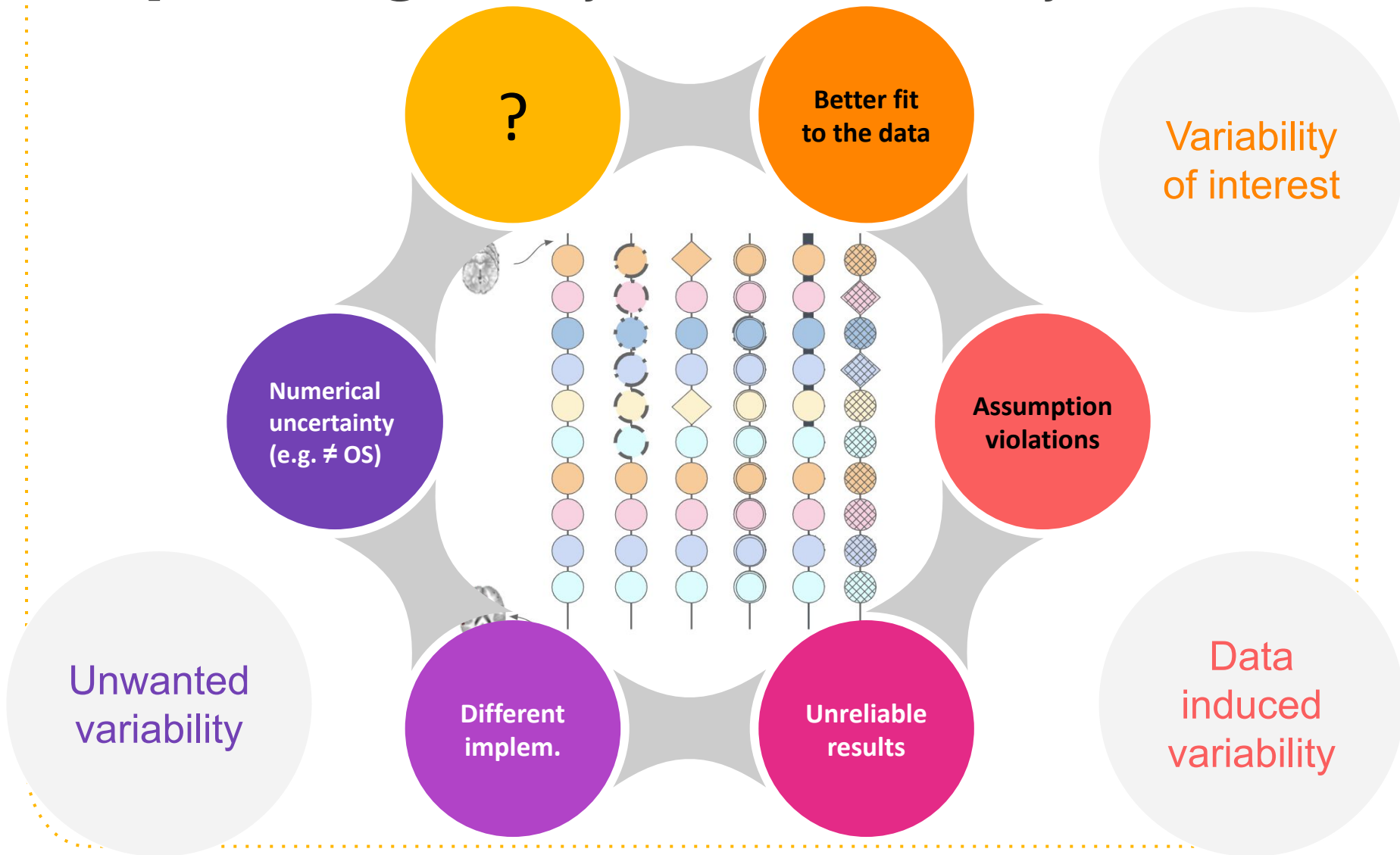
[Gronenschild 2012,  
Bowring 2019]



# Explaining analytical variability...



# Explaining analytical variability...

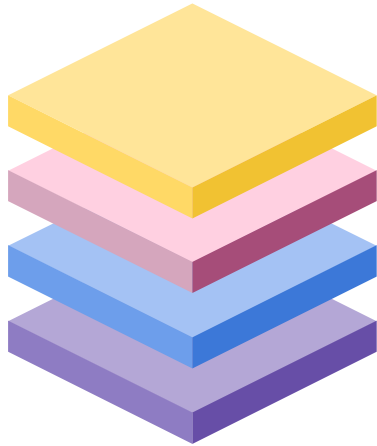




# On our way...

- Sharing a **variety of research artefacts** and in particular **code** along with paper
- Storing and **sharing provenance** (BIDS-Prov)
- **Benchmarking** different methods

*Special session* 10 years of reproducibility in biomedical research: how can we achieve generalizability and fairness?



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Thank you!

