



**HAL**  
open science

# Reproducible neuroimaging: a review on past and emerging questions

Camille Maumet

► **To cite this version:**

Camille Maumet. Reproducible neuroimaging: a review on past and emerging questions. 2023 - Journées Recherche reproductible: état des lieux, Mar 2023, Paris, France. , pp.1-27. hal-04020177v3

**HAL Id: hal-04020177**

**<https://inria.hal.science/hal-04020177v3>**

Submitted on 16 Mar 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

French network on reproducible research – Réseau de la recherche reproductible  
Journées Recherche reproductible: état des lieux

*Reproducible neuroimaging: a review  
on past and emerging questions*

—  
**Reproductibilité en neuroimagerie  
état des lieux**

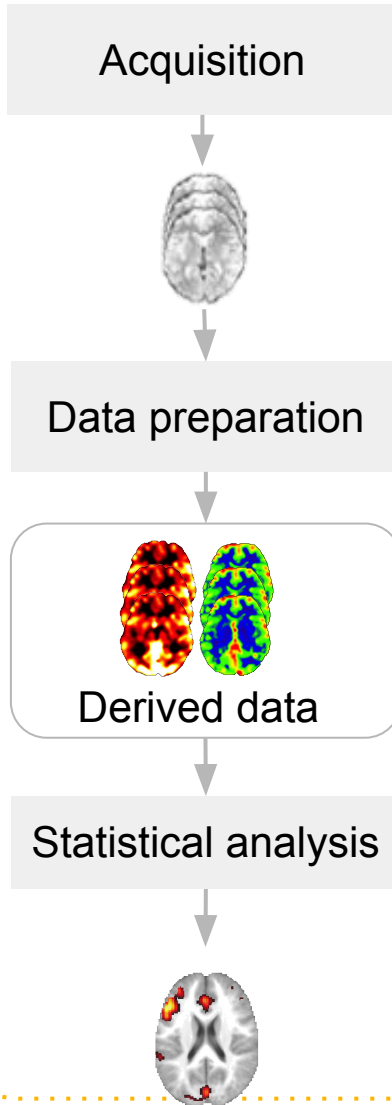
March 8, 2023

Camille Maumet

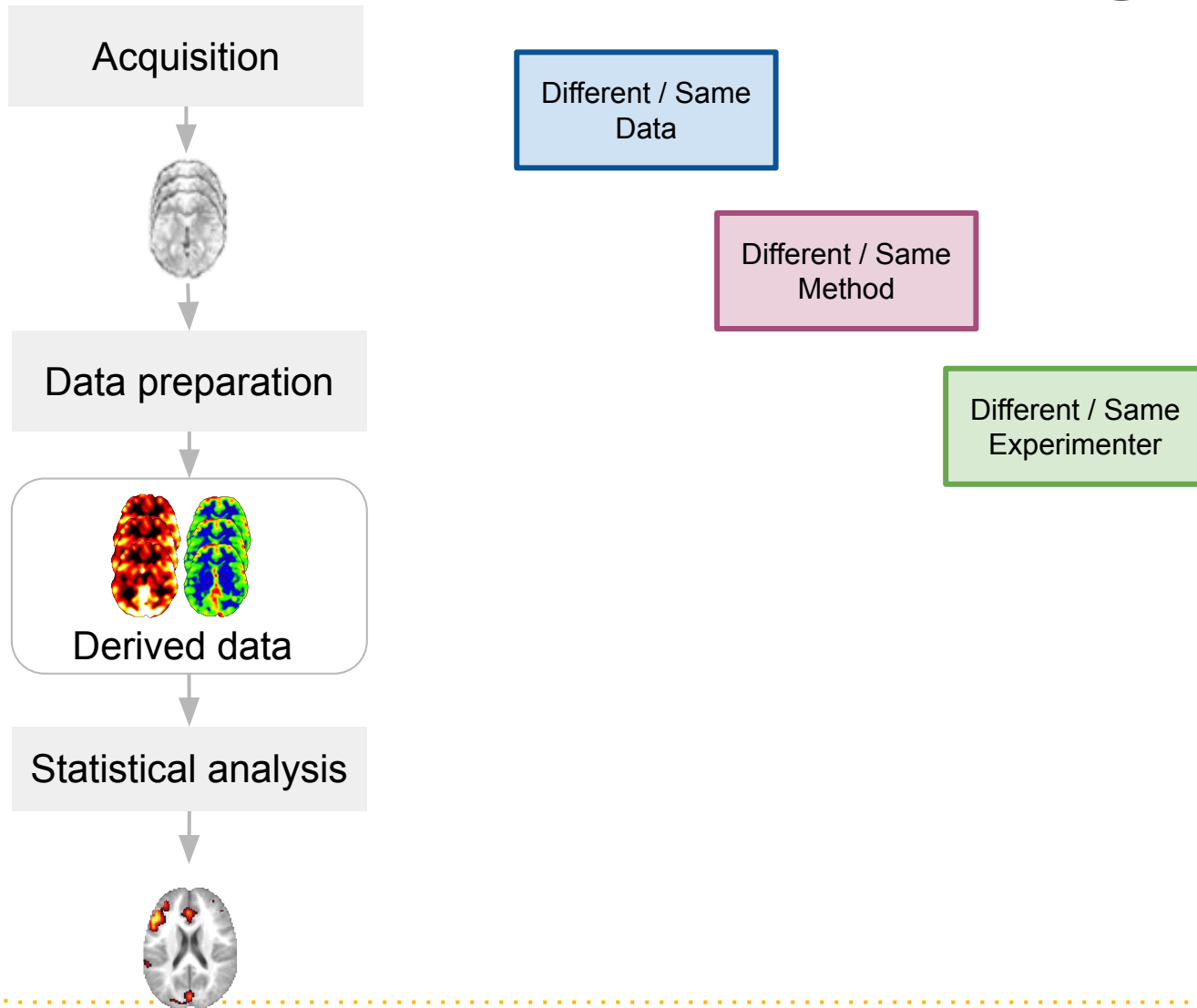
Univ Rennes, Inria, CNRS, Inserm

IL  
ECINE • NEUROSCIENCE • MATHEMATIQUES  
ISTOIRE • DROIT • ECONOMIE • PHILOSOPHIE  
S • GENETIQUE • ASTRONOMIE • ECOLOGIE  
ANTHROPOLOGIE • PSYCHOLOGIE • PHYSI  
CHIMIE • BIOLOGIE • SOCIOLOGIE • INFORMATI  
• MEDECINE • NEUROSCIENCE • CHIMIE  
JE • HISTOIRE • DROIT • ECONOMIE • CHIMIE  
E • RECHERCHE • REPRODUCTIBLE • FR • PH  
THEMATIQUES • MECANIQUE • GENETIQUE  
RONOMIE • PHILOSOPHIE • ANTHROPOLOGIE  
PSYCHOLOGIE • ECOLOGIE • DROIT • CHIMIE  
IOLOGIE • SOCIOLOGIE • ASTROPHYSIQUE  
DECINE • NEUROSCIENCE • ECONOMIE • A  
PIDEMIOLOGIE • HISTOIRE • ECONOMIE • A  
HEMATIQUES • MECANIQUE • GENETIQUE • A  
**INSTITUT PASTEUR**  
**8 & 9 MARS 2023**  
IENCE • RECHERCHE • ROBUSTE • REPLICABLE  
RALISABLE • EXPERIENCE • CODE • OBSERVATION  
STATISTIQUES • REPRODUCTIBLE • ANALYSE  
ES • NUMERIQUE • RESULTAT • METHODE • F  
E • SCIENCE • ETAT • ECHANTILLON • ROBU  
ICABLE • GENERALISABLE • STATISTIQUES • ANALY  
JE • OBSERVATION • STATISTIQUES • RESULTAT • M  
NEES • EXPERIENCE • REPLICABLE • ROBU  
RECHERCHE • SCIENCE • REPLICABLE • EXPERIEN  
GENERALISABLE • ANALYSE

# Reproducible brain imaging



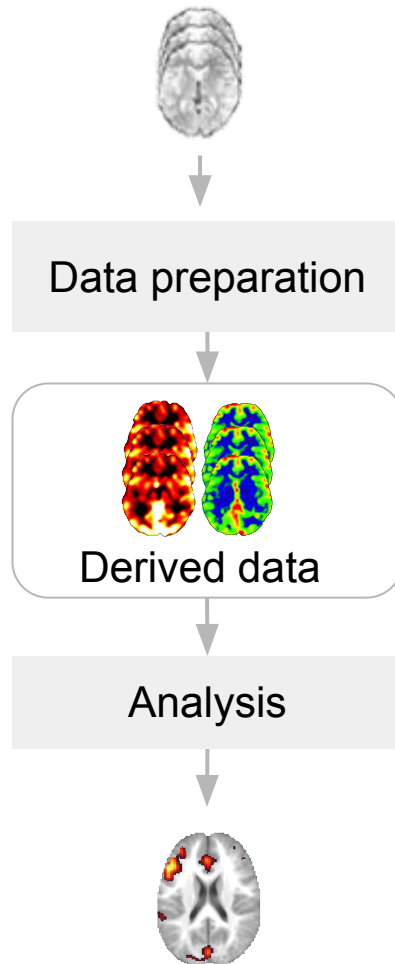
# Reproducible brain imaging



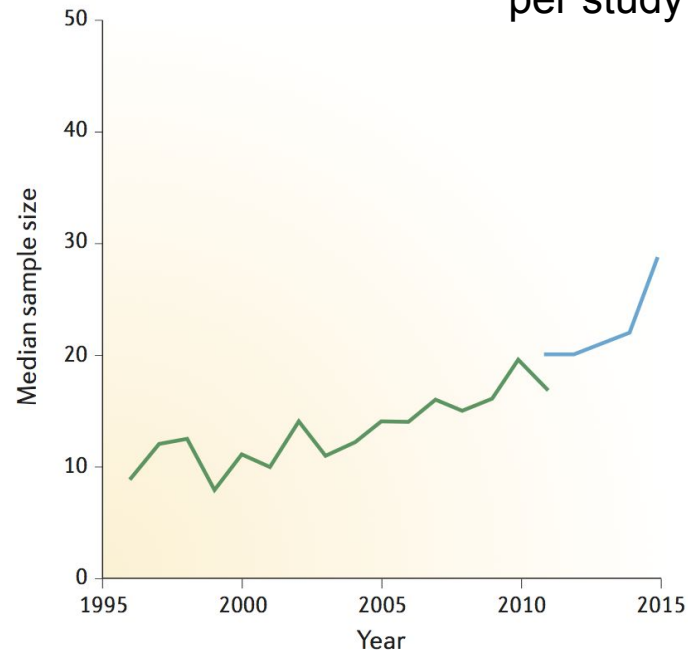
# Towards **reproducible** neuroimaging

Irreproducible with...

Different Data



about 30 participants  
per study



[Poldrack et. al, Nature Neuroscience 2017]

# Towards **reproducible** neuroimaging

Irreproducible with...

Different Data

# Towards **reproducible** neuroimaging

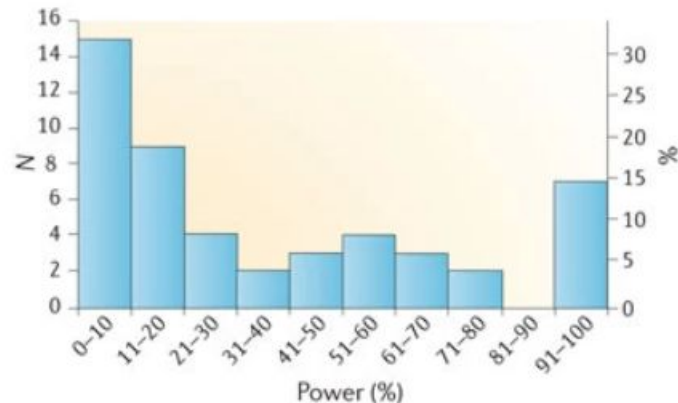
Irreproducible with...

Different Data

## Lack of power

### 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]

We need bigger datasets

# Towards **reproducible** neuroimaging

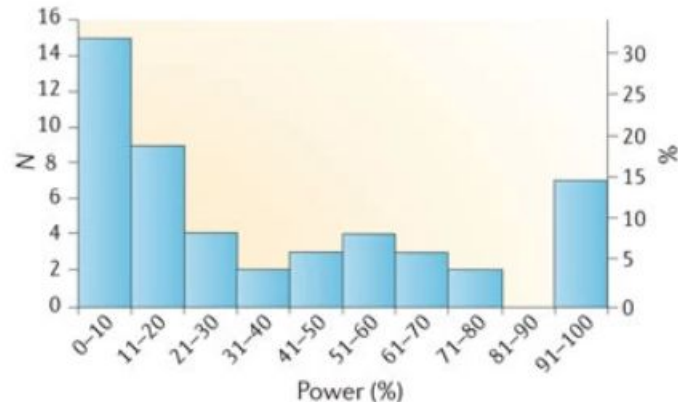
Irreproducible with...

Different Data

## Lack of power

### Power of neuroscience studies

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

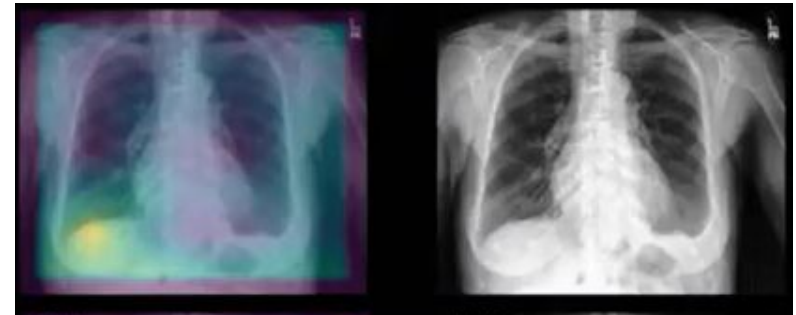


[Button et. al, Nat Rev Neurosci 2013]

## Generalizability and fairness

### X-ray: Lung opacity detection

Model trained on male images, tested on female images



[Larrazabal et. al, PNAS 2020]

We need bigger datasets

We need representative and diverse datasets





# 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



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

Consortium  
1000 participants



ABIDE  
Autism Brain Imaging  
Data Exchange

1000 Functional  
Connectomes Project



CORR  
CONSORTIUM FOR  
RELIABILITY AND  
REPRODUCIBILITY



NITRC

OSF

- + Images
- + Homogenous
- Datasets



# 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

Consortium  
1000 participants



ABIDE  
Autism Brain Imaging  
Data Exchange

1000 Functional  
Connectomes Project



CORR  
CONSORTIUM FOR  
RELIABILITY AND  
REPRODUCIBILITY



Cohort  
100 000 participants



HUMAN  
Connectome  
PROJECT

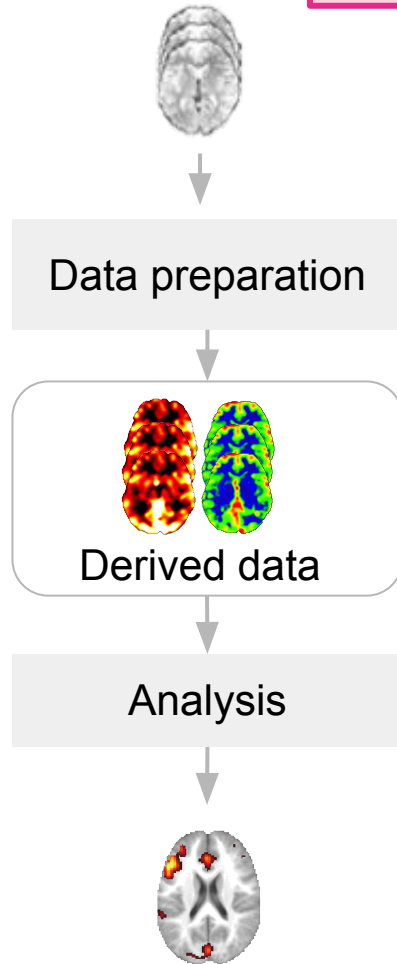
biobank<sup>uk</sup>  
Improving the health of future generations

- + Images
- + Homogenous
- Datasets

# On our way **to fix irreproducibility**

Irreproducible with...

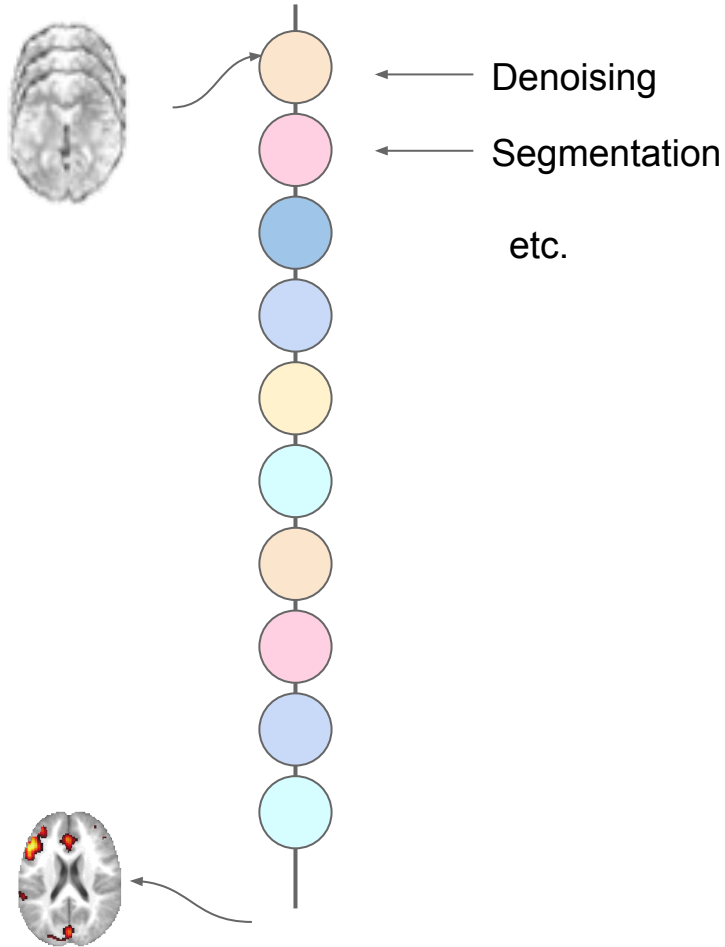
Different Post-processing Methods



# On our way **to fix irreproducibility**

Irreproducible with...

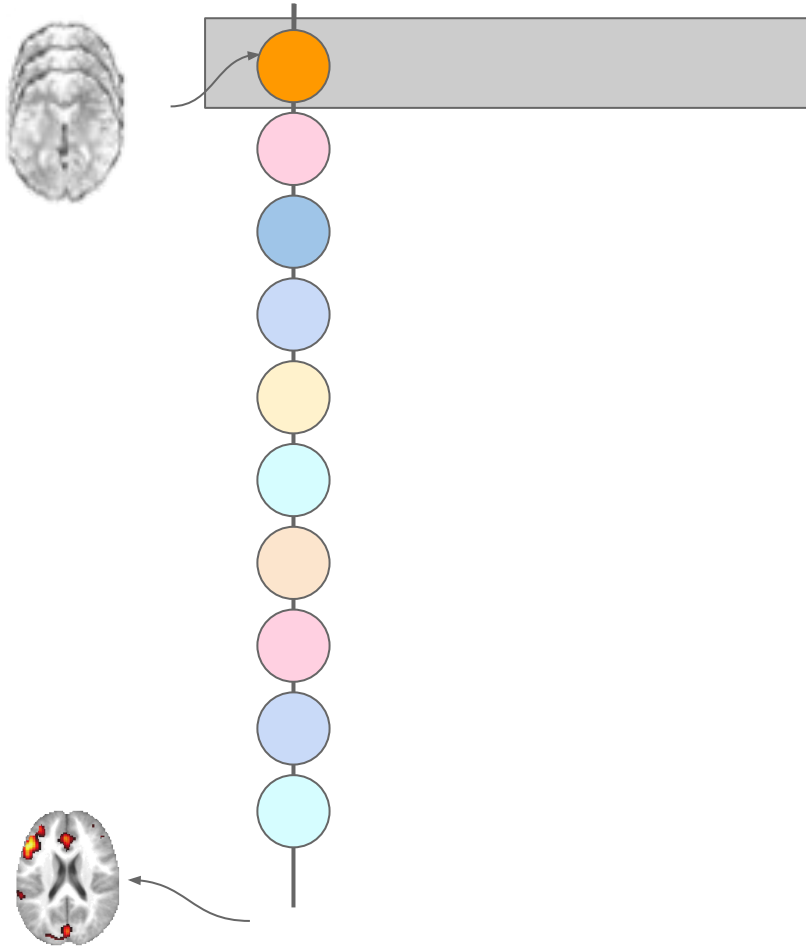
Different Post-processing Methods



# On our way **to fix irreproducibility**

Irreproducible with...

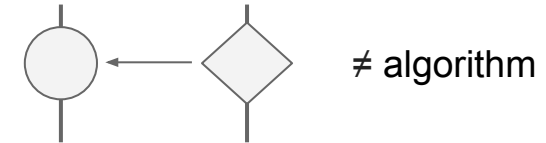
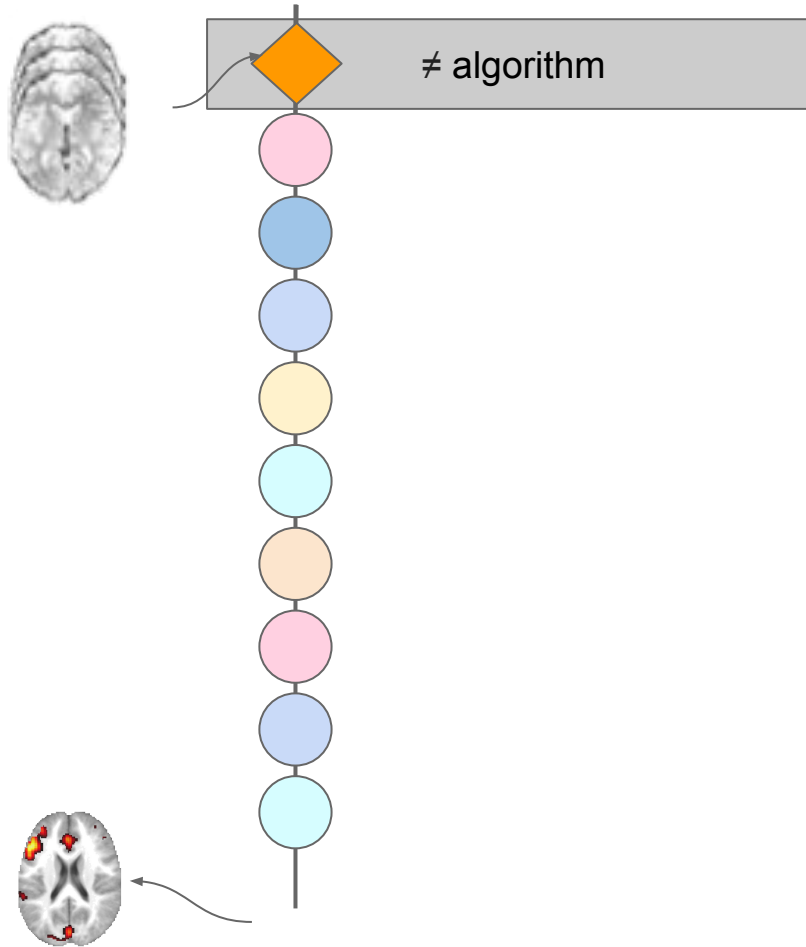
Different Post-processing Methods



# On our way **to fix irreproducibility**

Irreproducible with...

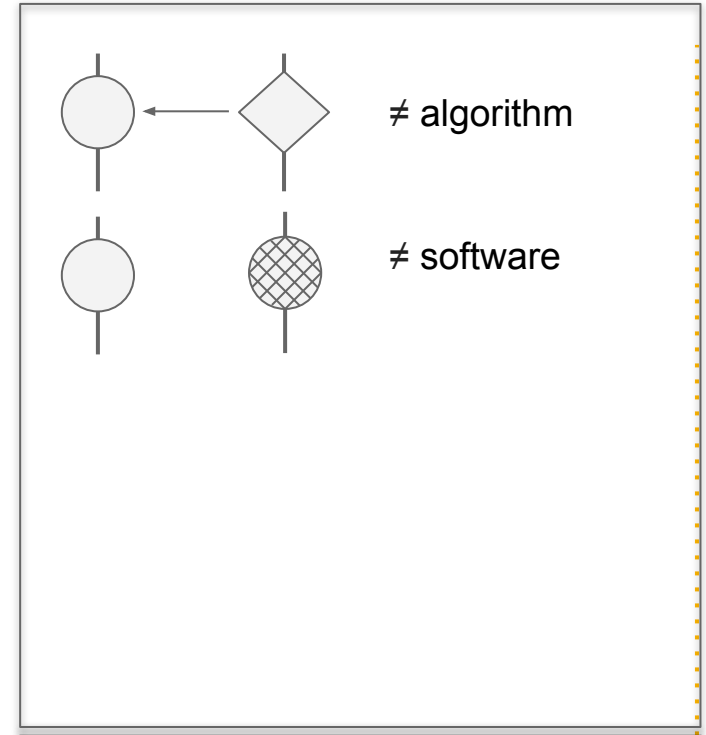
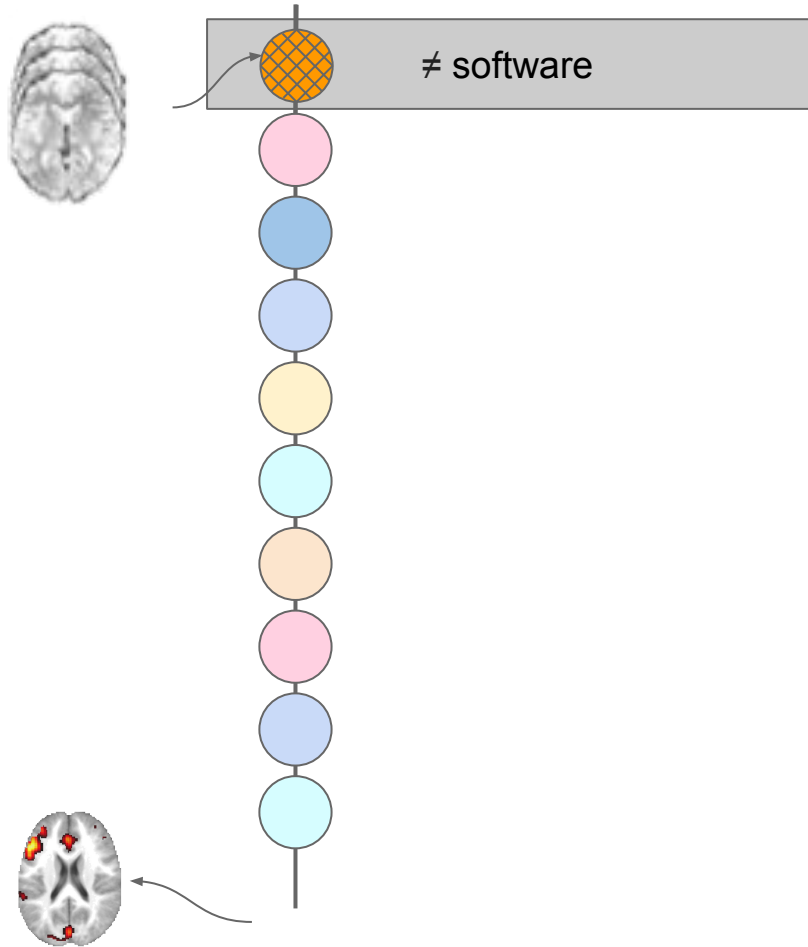
Different Post-processing Methods



# On our way **to fix irreproducibility**

Irreproducible with...

Different Post-processing Methods

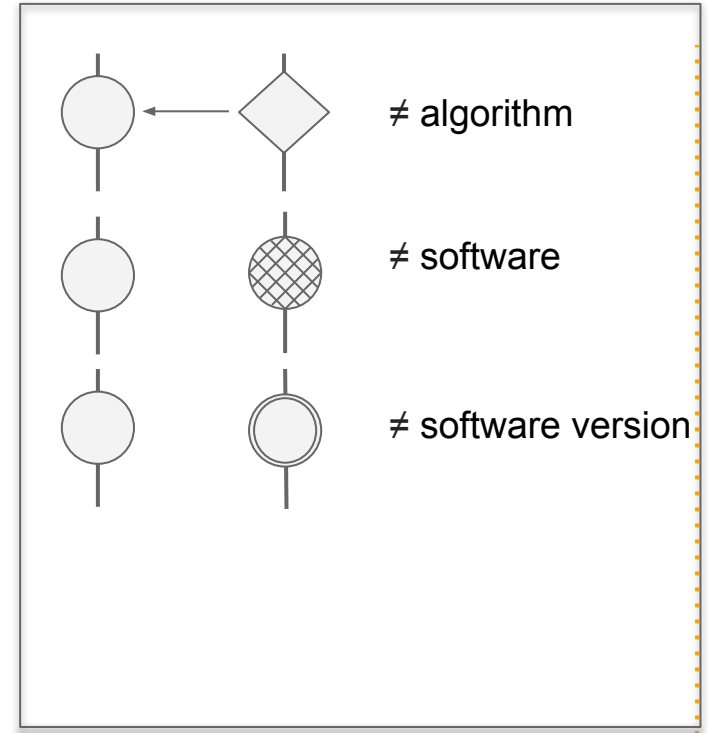
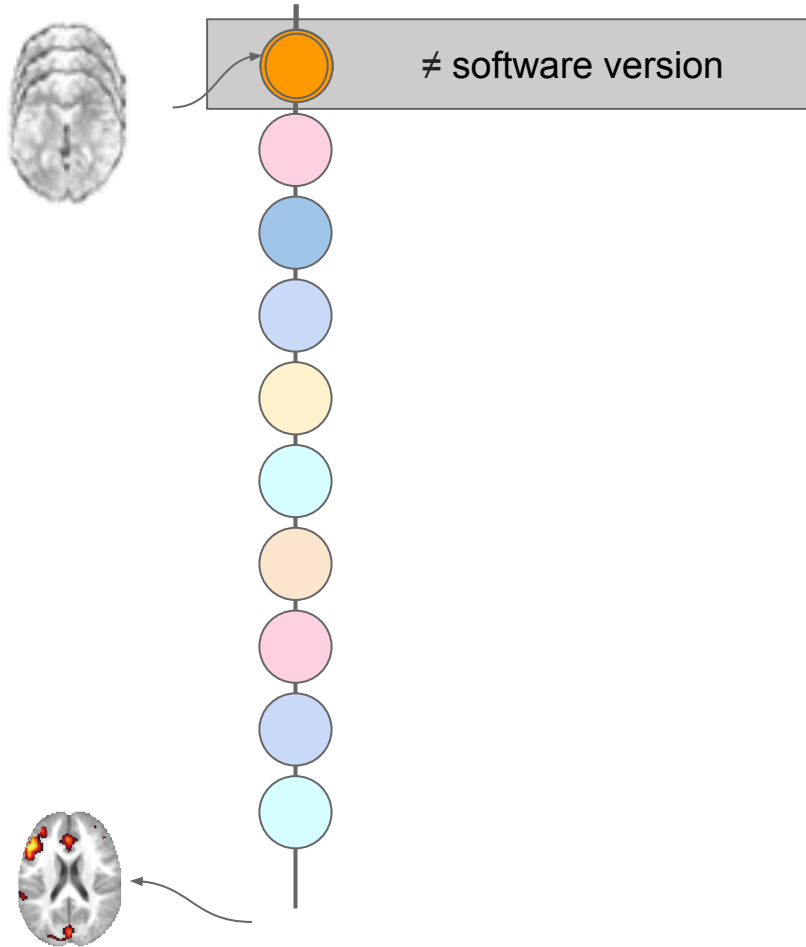




# On our way **to fix irreproducibility**

Irreproducible with...

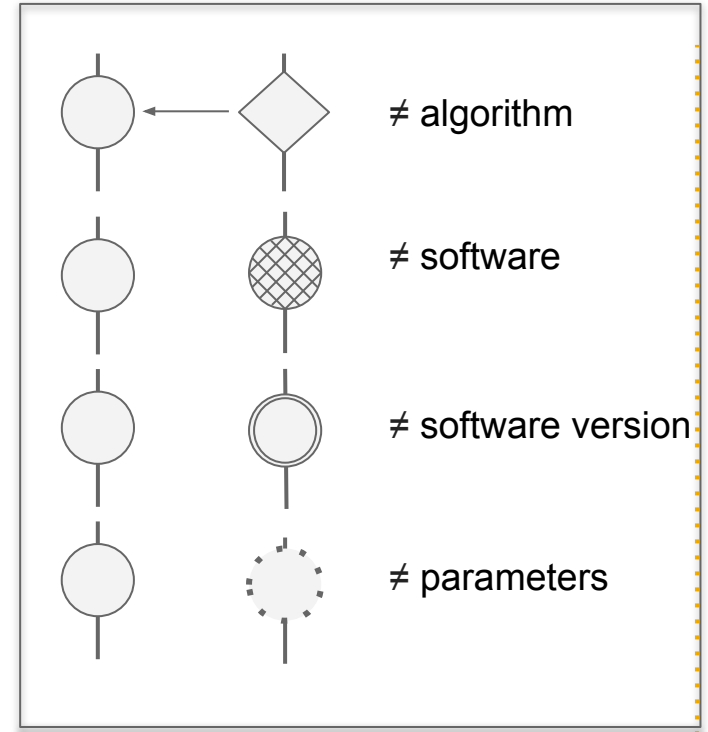
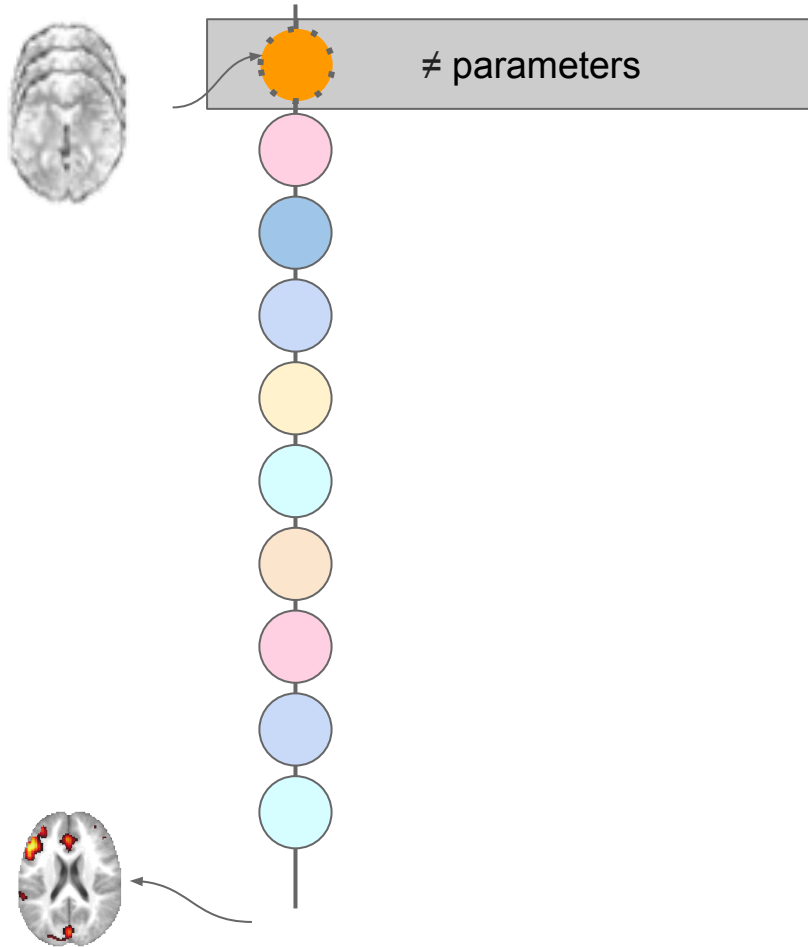
Different Post-processing Methods



# On our way **to fix irreproducibility**

Irreproducible with...

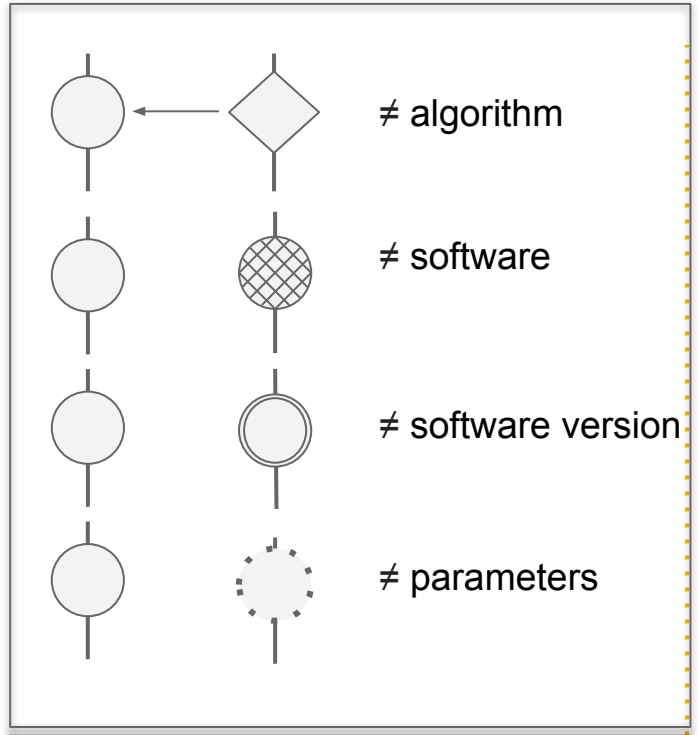
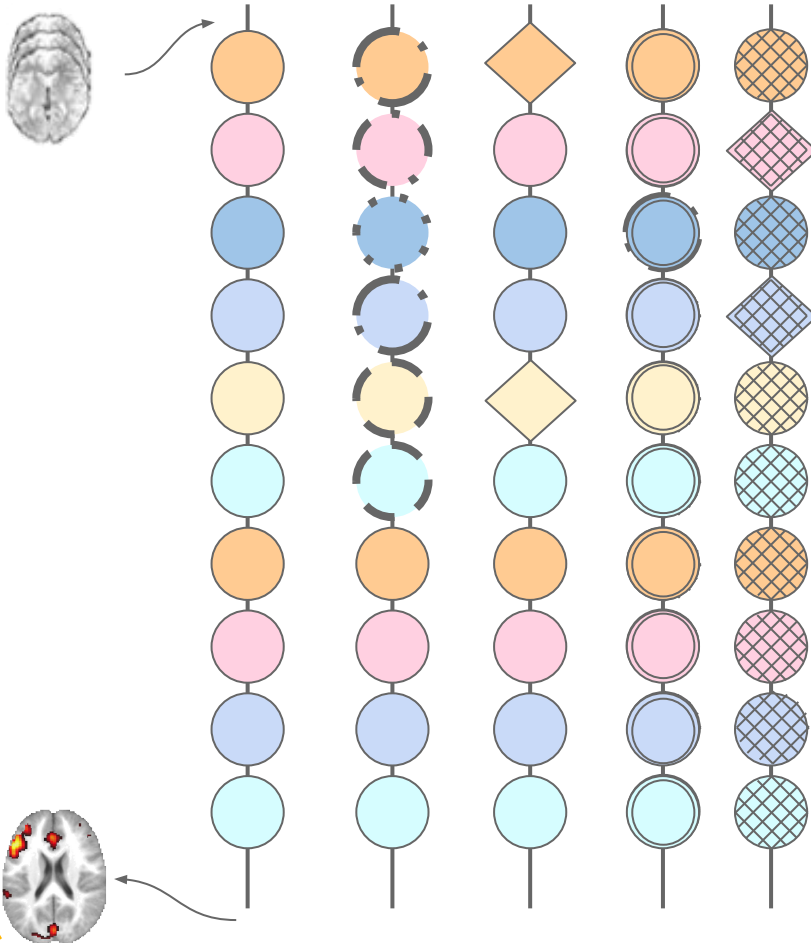
Different Post-processing Methods



# On our way to fix irreproducibility

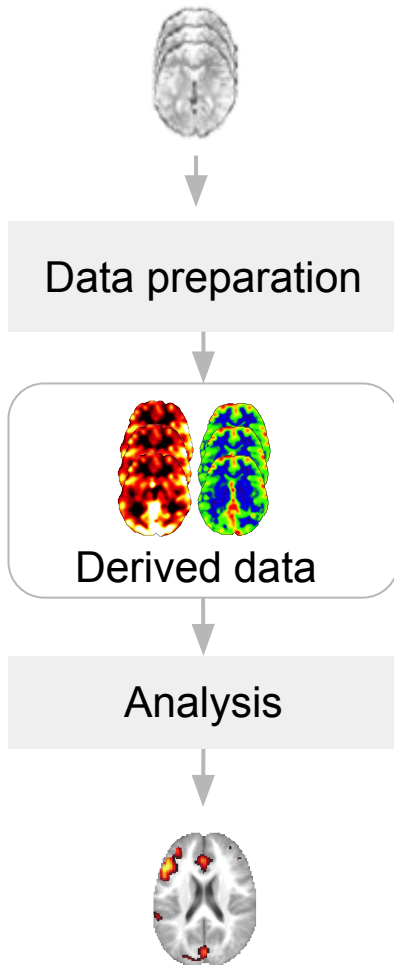
Irreproducible with...

Different Post-processing Methods

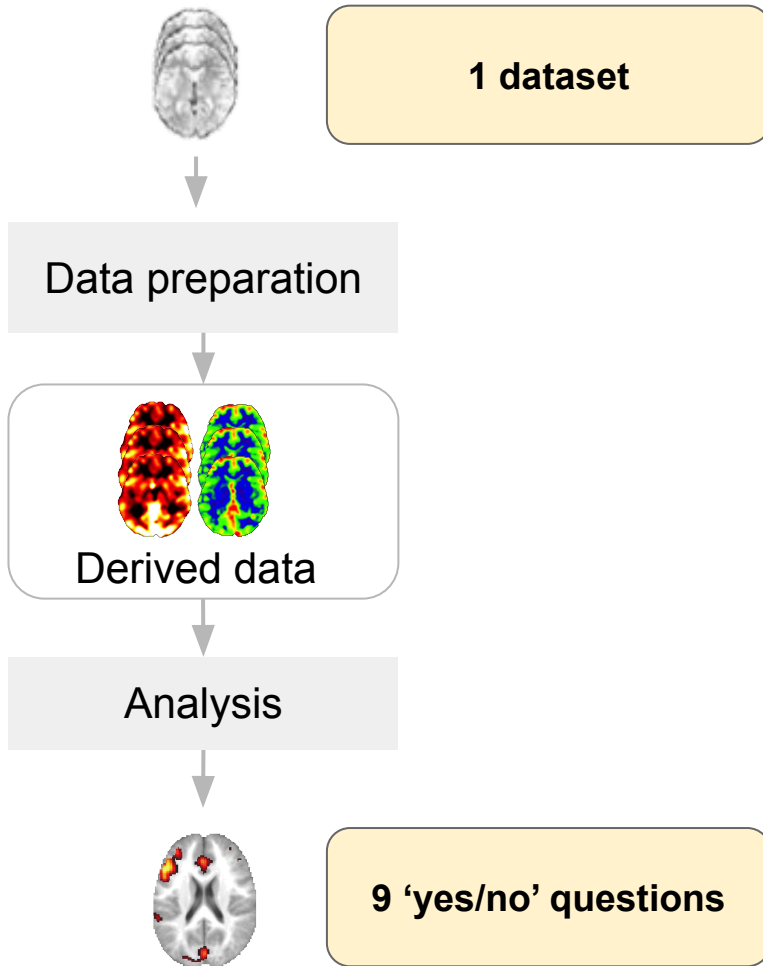


**A family of acceptable pipelines**  
over  $10^{30}$  combinations...

# Many analysts project : NARPS

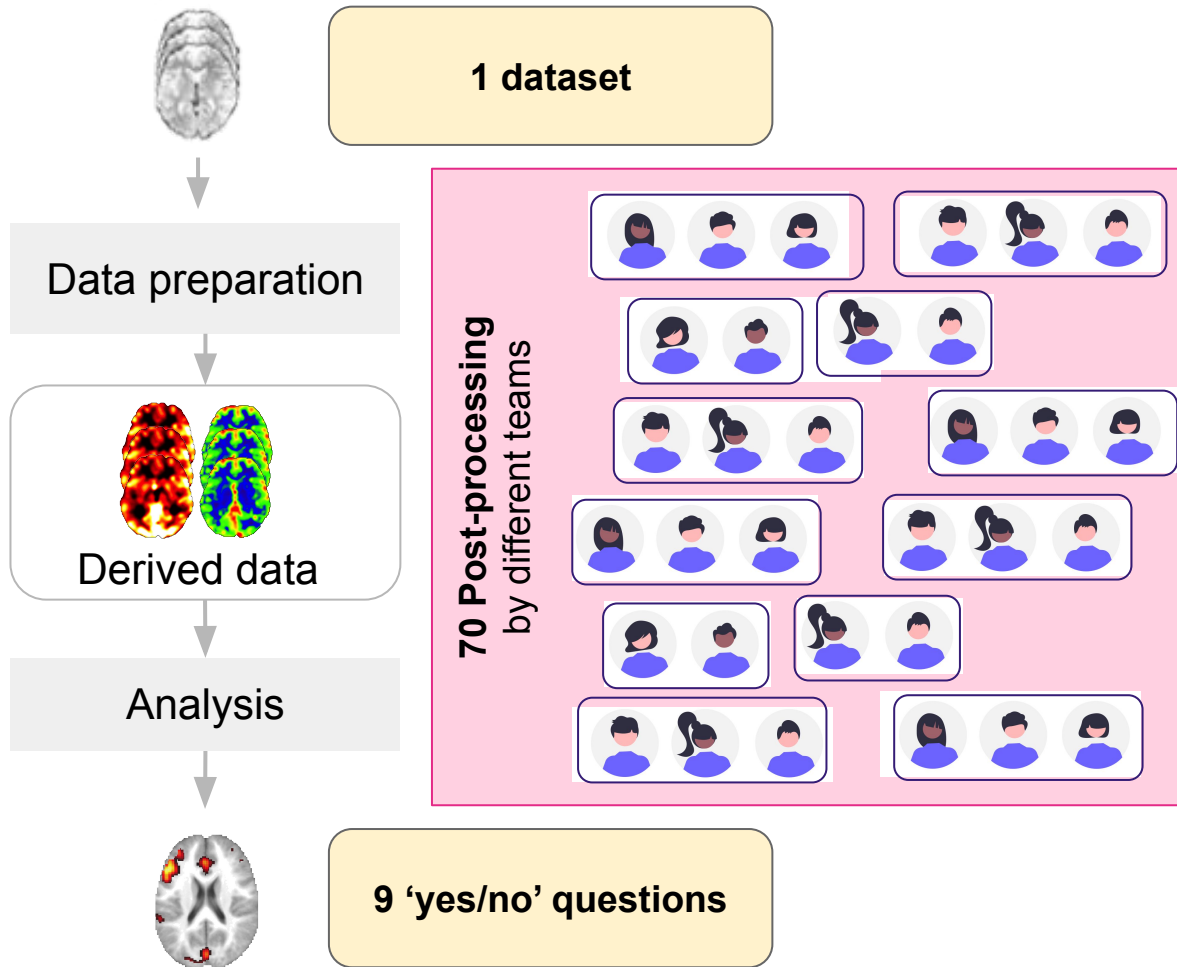


# Many analysts project : NARPS



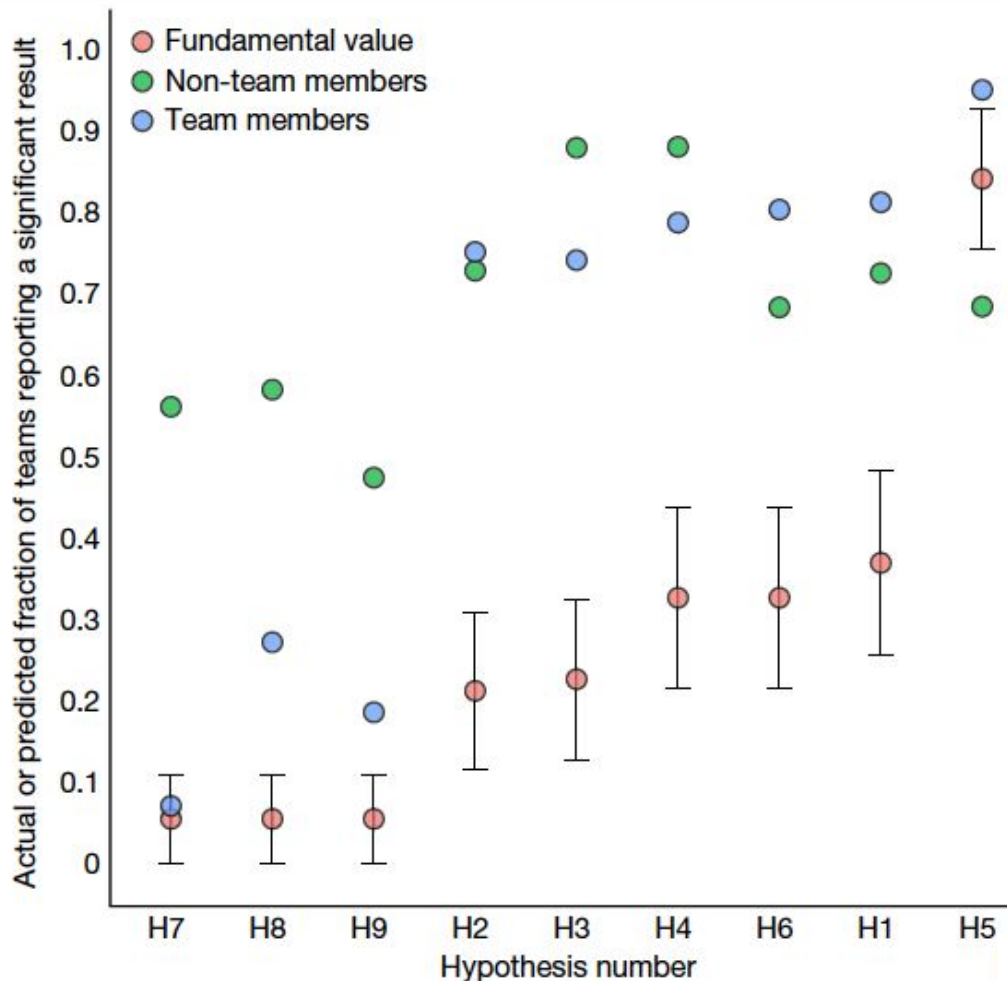
*e.g. Is there a parametric effect of gain:  
Positive effect in ventromedial PFC -  
for the equal indifference group?*

# Many analysts project : NARPS



# Many analysts project : NARPS

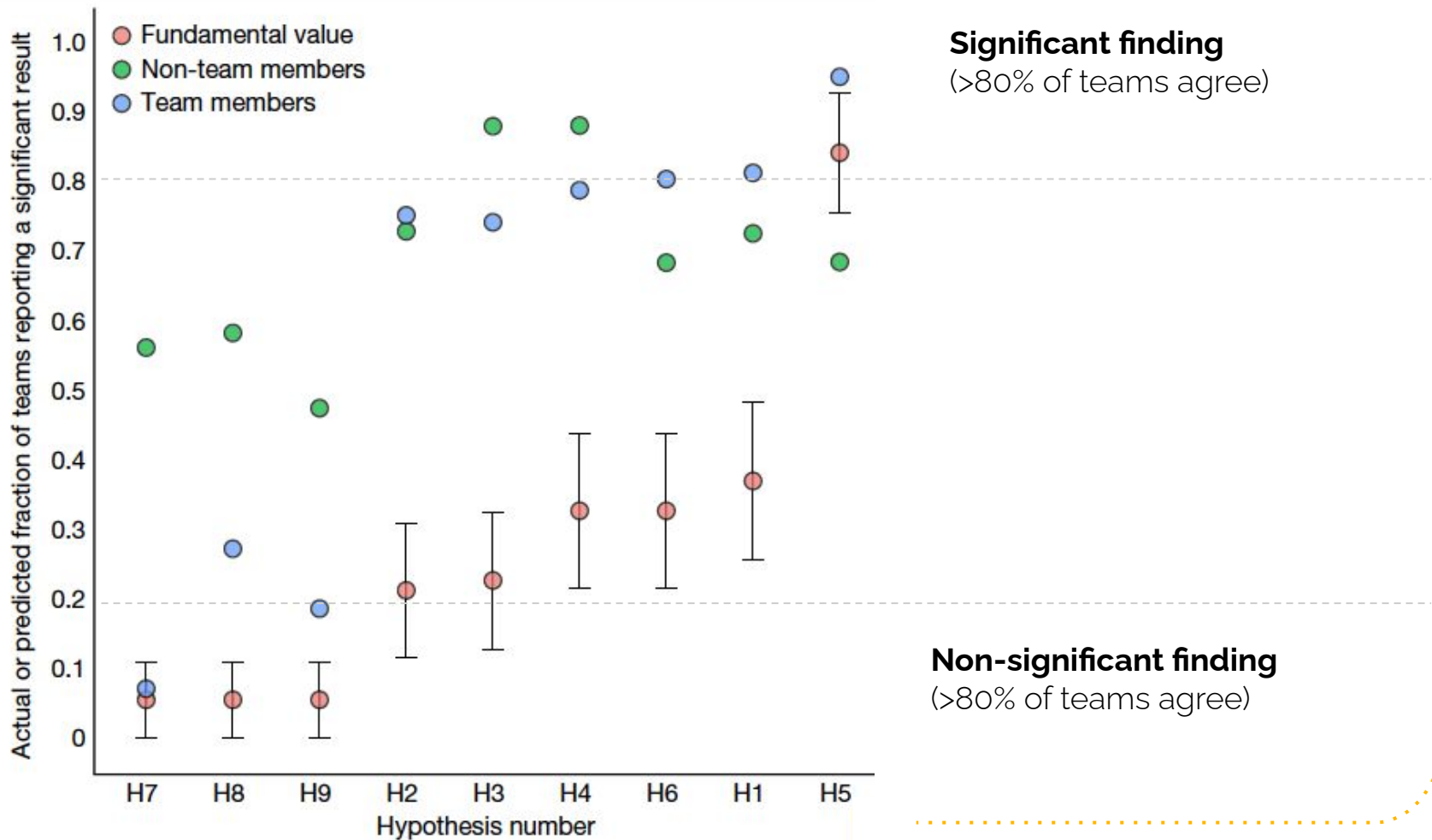
Results over the **70 post-processing pipelines**:



[Botvinik-Nezer et. al, Nature 2020]

# Many analysts project : NARPS

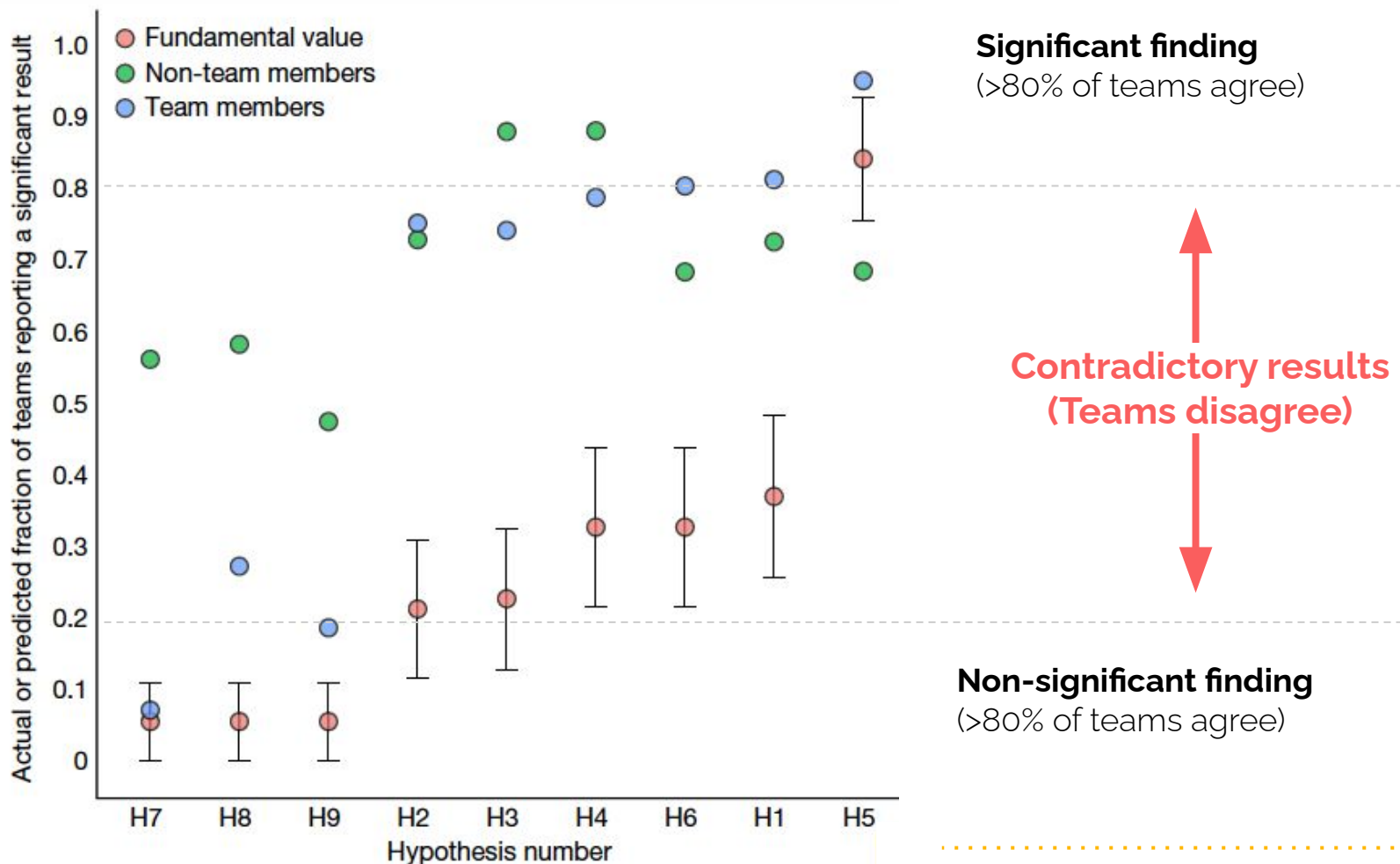
Results over the **70 post-processing pipelines**:





# Many analysts project : NARPS

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



# Different levels of variability in 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]

# Open questions

## Stratégie adoptée par votre communauté

- **sur le plan technique**
  - Partage de code
- **pour les carrières**
  - Data papers
- **en terme d'Animation**
  - Open science community (OHBM open science SIG, Brainhack)
  - Hackathons collaboratifs "Brainhack"

## Exemple de problèmes techniques et scientifiques

- Open data in Europe (GDPR, infrastructures)
- Causes of analytical variability (different methods) not well understood

Réseau de la recherche reproductible Journées Recherche  
reproductible: état des lieux

March 8, 2023

**Reproductibilité** computationnelle en **neuroimagerie**:  
*état des lieux*

Camille Maumet

Merci



Credit: Sculpture by Malin Bjornsdotter "Cerebia", [OHBM Brain Art SIG](#); Presentation template by [SlidesCarnival](#), adapted

 [@cmaumet@fediscience.org](https://@cmaumet@fediscience.org)

 [@cmaumet](https://@cmaumet)