



Towards large-scale brain imaging studies

Camille Maumet

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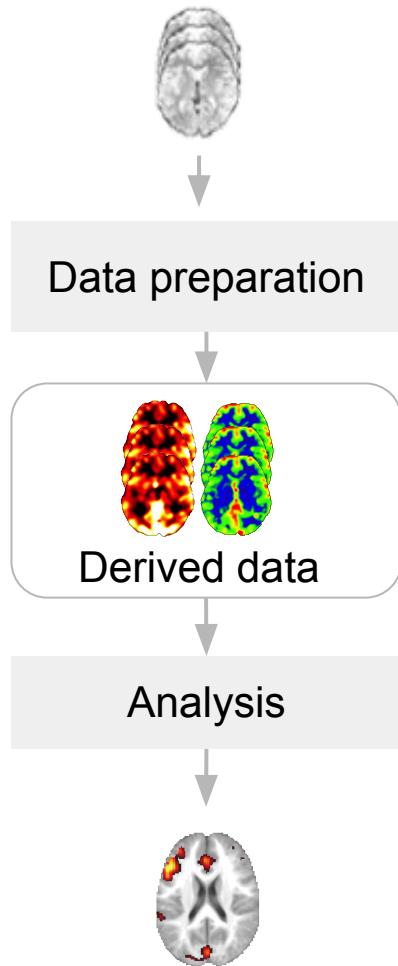
Towards **large-scale** brain imaging studies



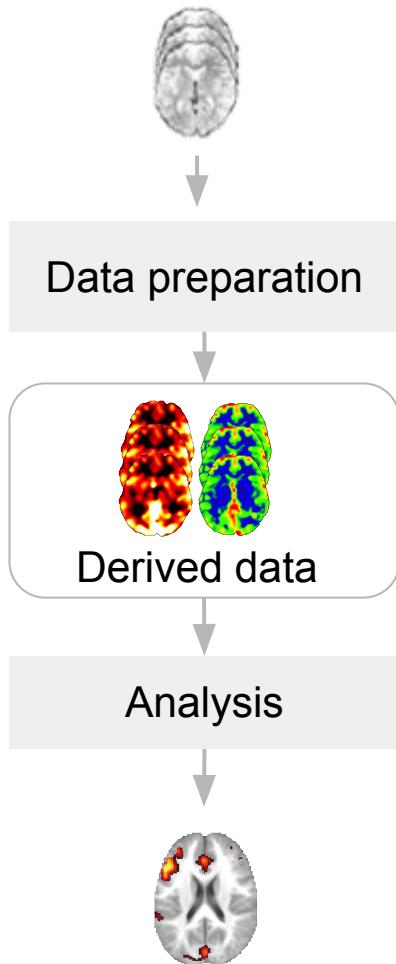
Camille Maumet
Univ Rennes, Inria, CNRS, Inserm



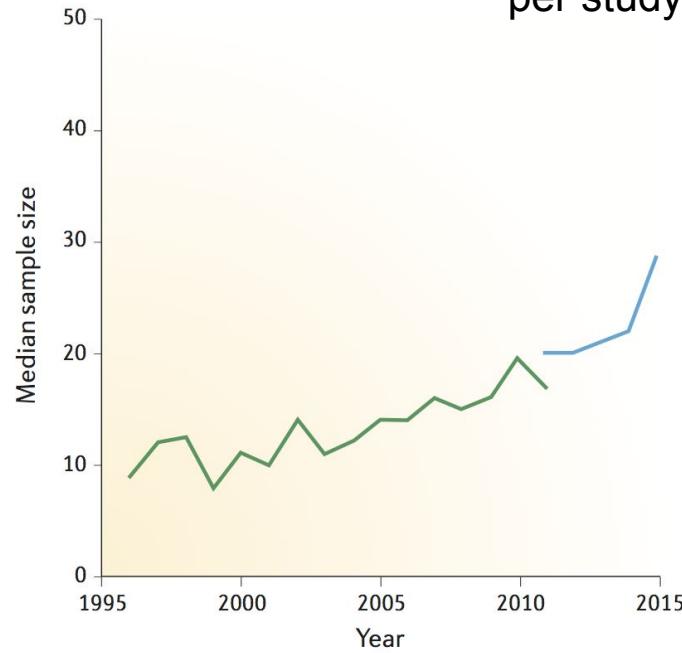
A brain imaging study



A brain imaging study



about 30 participants
per study



[Poldrack et. al, Nature Neuroscience 2017]

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

(Ir)-Reproducibility

Why are middle-aged marathon runners faster than twentysomethings?

According to new data from the running app Strava, runners in their 40s are streets ahead of younger rivals



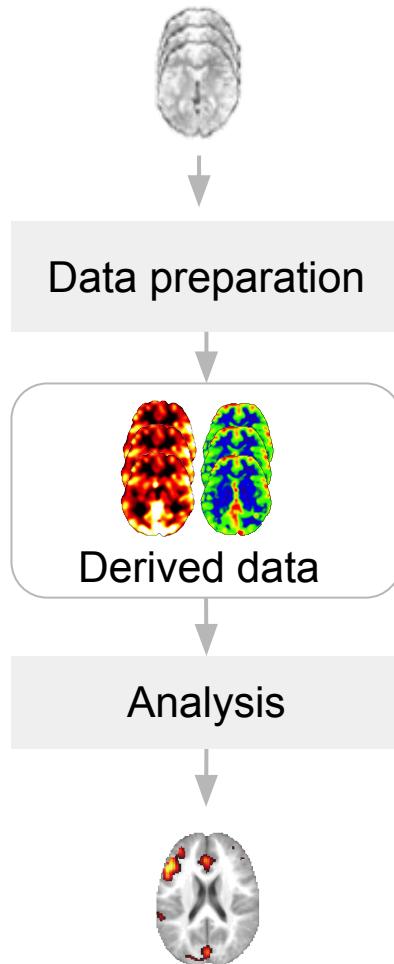
▲ 'Middle-aged runners outperform runners in the 20s ...' Photograph: FatCamera/Getty

According to data released by the running app Strava, middle-aged runners consistently average faster marathon times than their younger rivals, apparently defying the usual rules of athletic performance. Men in the 40-49 age bracket clock an average time of four hours and 17 minutes for a marathon, according to the recent figures. Women in the same age range typically come in at just under the five-hour mark.

Faster in their forties than twentysomethings?

Selection bias

A brain imaging study



We need **bigger** & more
representative samples

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

NITRC

OSF

Consortium
1000 participants



ABIDE
Autism Brain Imaging
Data Exchange



CORR
CONSORTIUM FOR
RELIABILITY AND
REPRODUCIBILITY



- + Images
- + Homogenous
- Datasets



Open data

Unique study
30 participants



OpenNEURO



Consortium
1000 participants



Autism Brain Imaging
Data Exchange



CONSORTIUM FOR
RELIABILITY AND
REPRODUCIBILITY

1000 Functional
Connectomes Project



- + Images
- + Homogenous
- Datasets



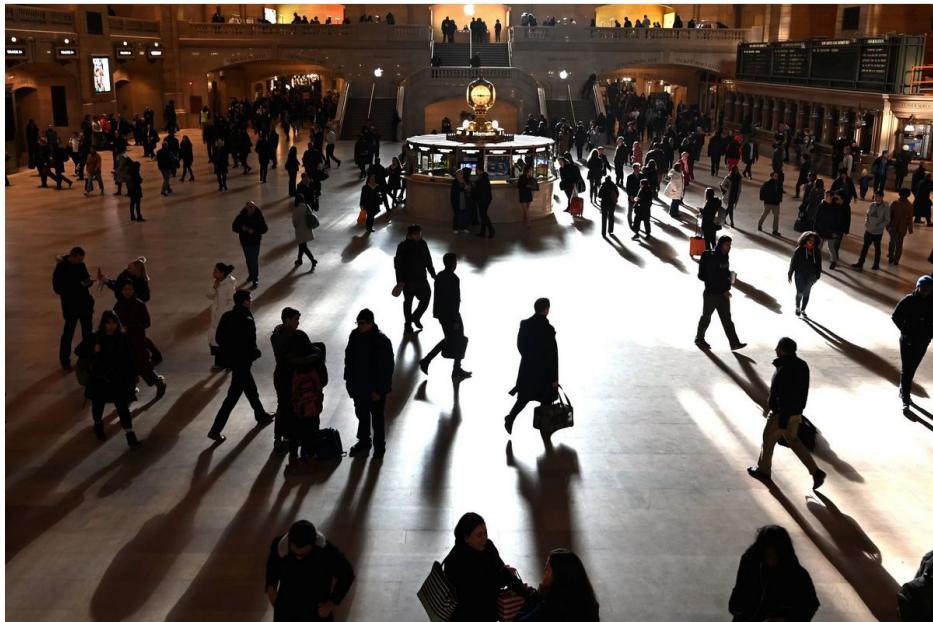
Cohort
100 000 participants



The New York Times

Many Facial-Recognition Systems Are Biased, Says U.S. Study

Algorithms falsely identified African-American and Asian faces 10 to 100 times more than Caucasian faces, researchers for the National Institute of Standards and Technology found.



Morning at Grand Central Terminal. Technology for facial recognition is frequently biased, a new study confirmed. Timothy A. Clary/Agence France-Presse — Getty Images

Lack of diversity of the input data

Algorithmic bias

OPT-OUT CULTURE

Using a fitness app taught me the scary truth about why privacy settings are a feminist issue



The social fitness app Strava is meant to help people compare data on their workouts.

REUTERS/EDDIE KEOGH

FROM OUR SERIES

Ideas

Our home for bold arguments and big thinkers.



By **Rosie Spinks**

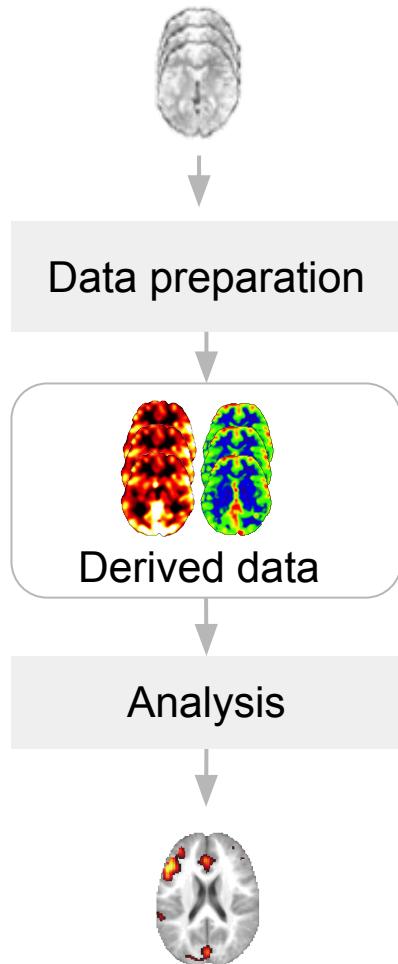
August 1, 2017 • This article is more than 2 years old.

Lack of diversity of the team

Data privacy

Quartz, "[Using a fitness app taught me the scary truth about why privacy settings are a feminist issue](#)", R. Spinks, 2017.

A brain imaging study

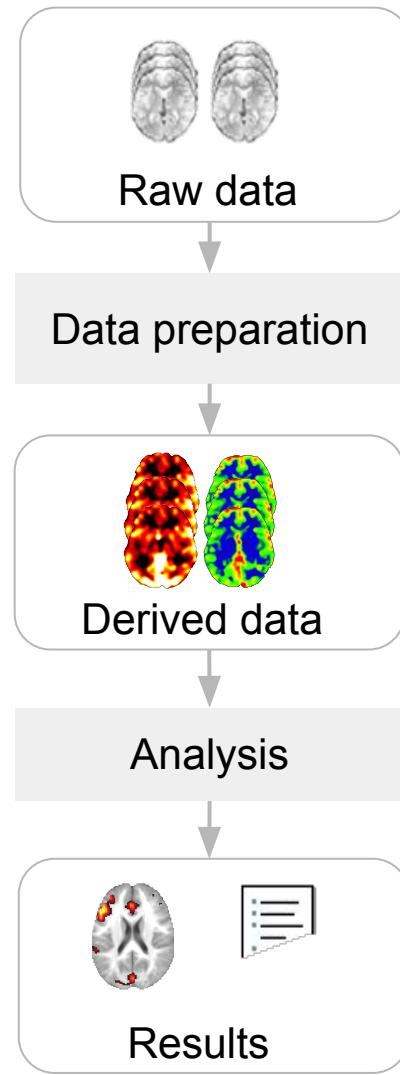


We need **bigger** and
representative samples

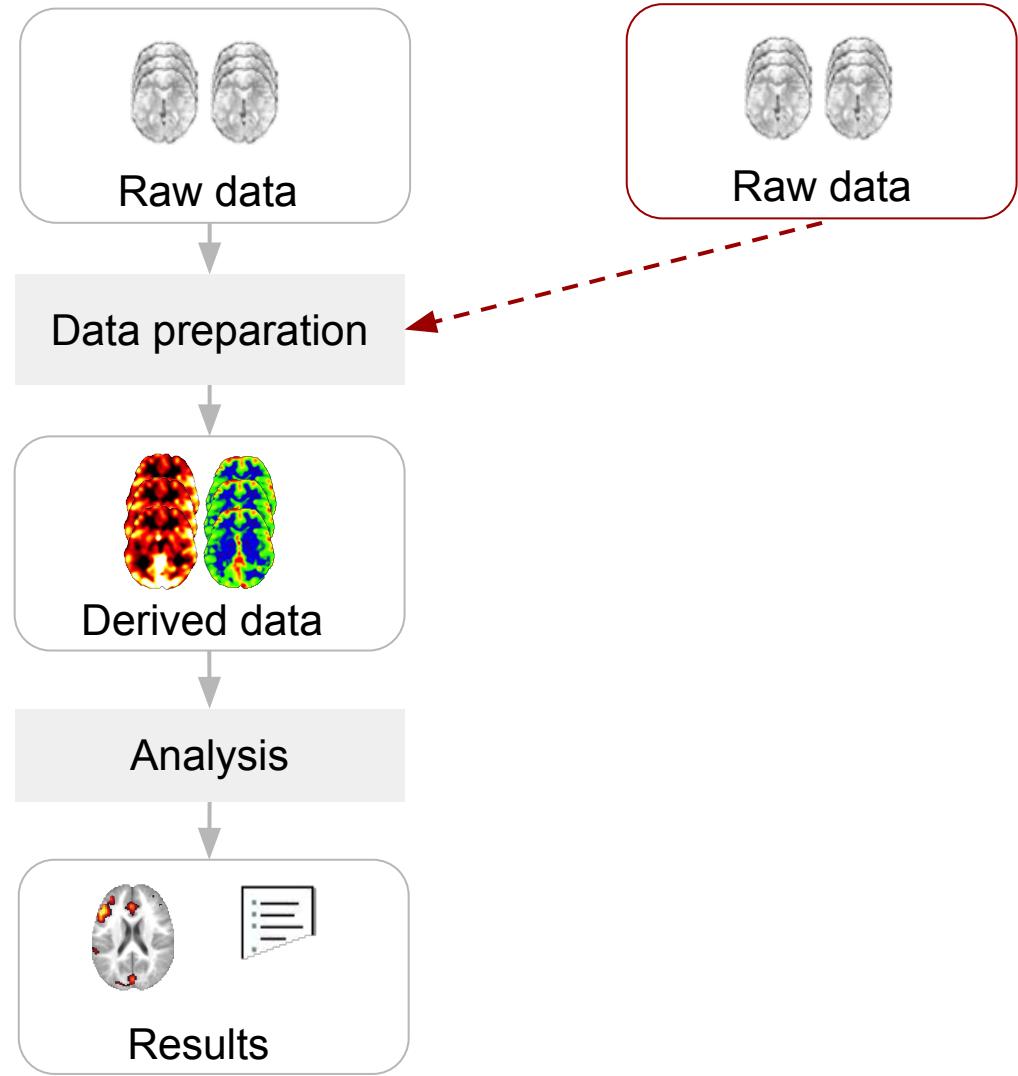
We need **diversity** in
datasets *and* in
leadership teams

Data integration

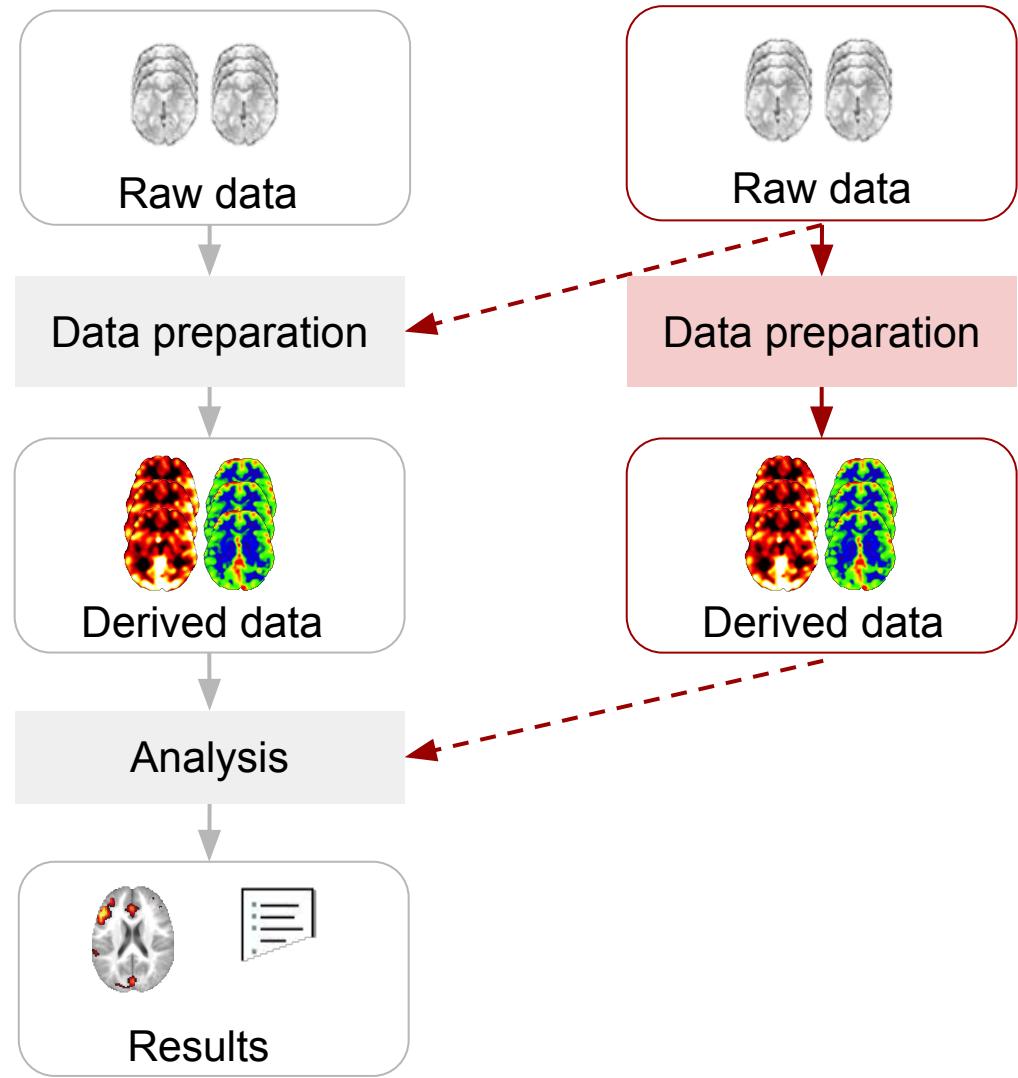
Data integration



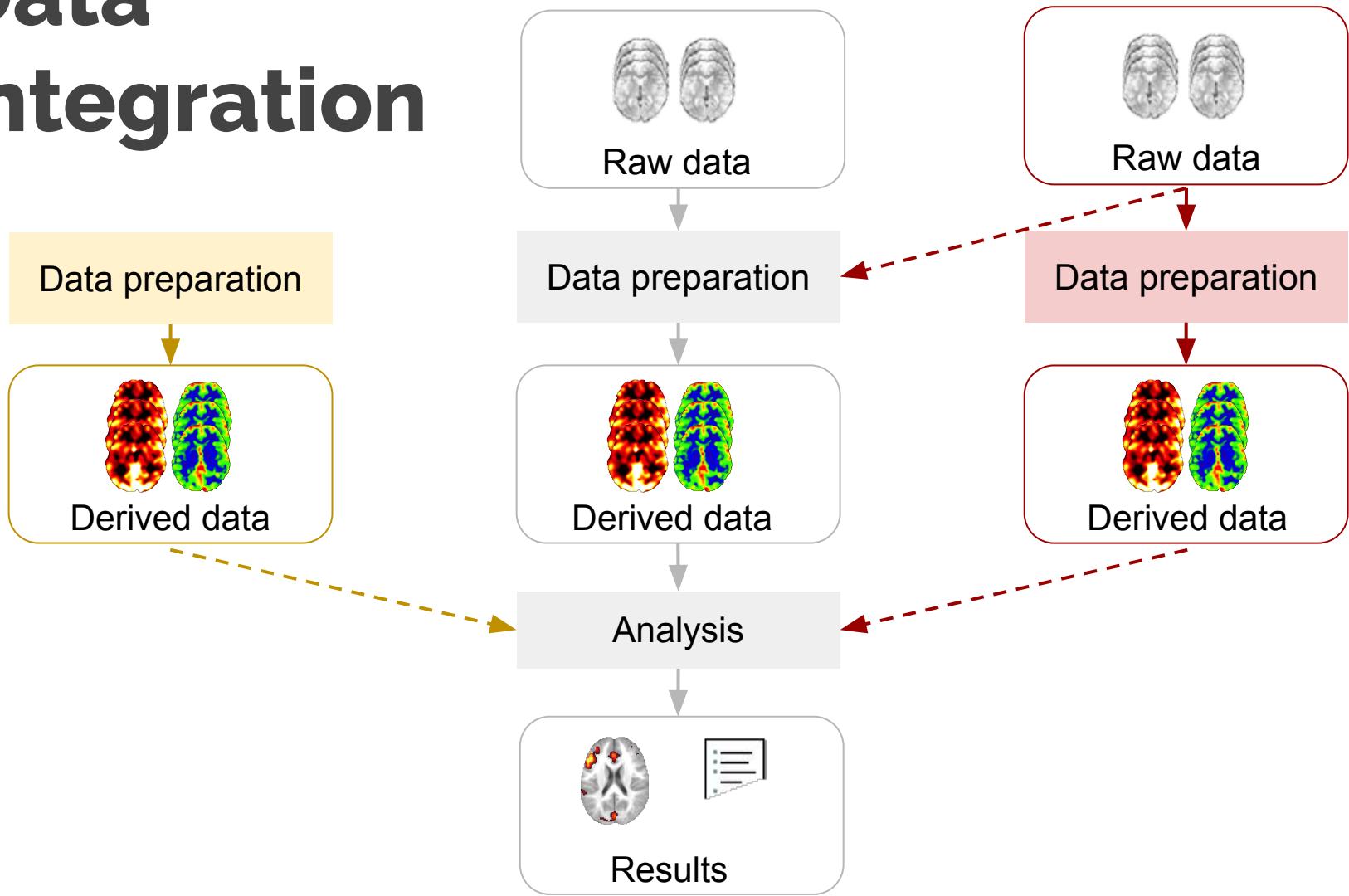
Data integration



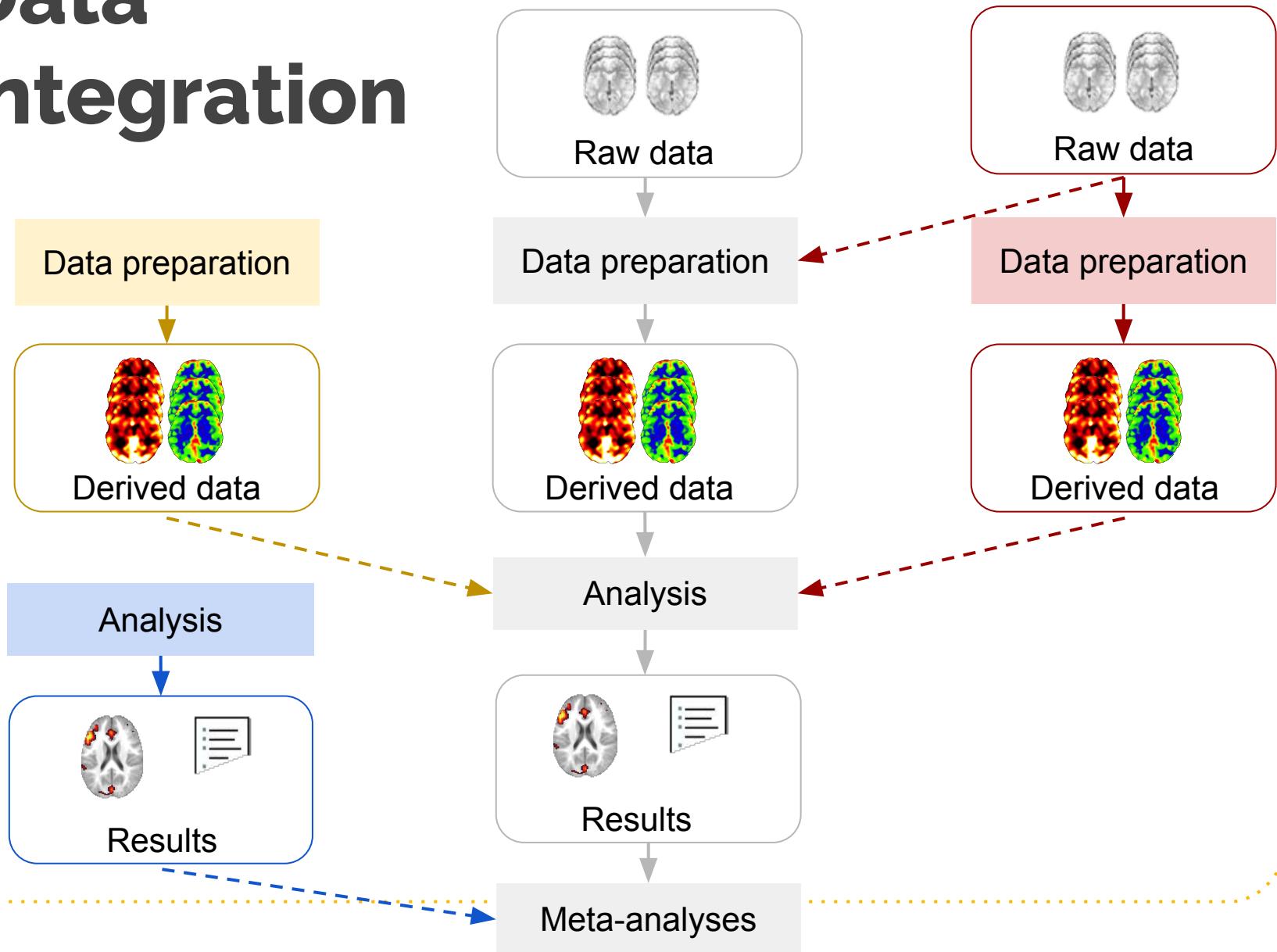
Data integration



Data integration



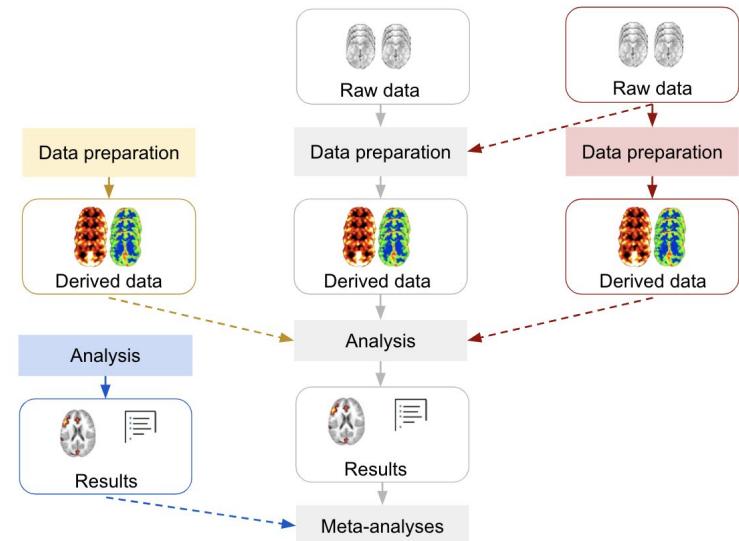
Data integration



A new level of
variability

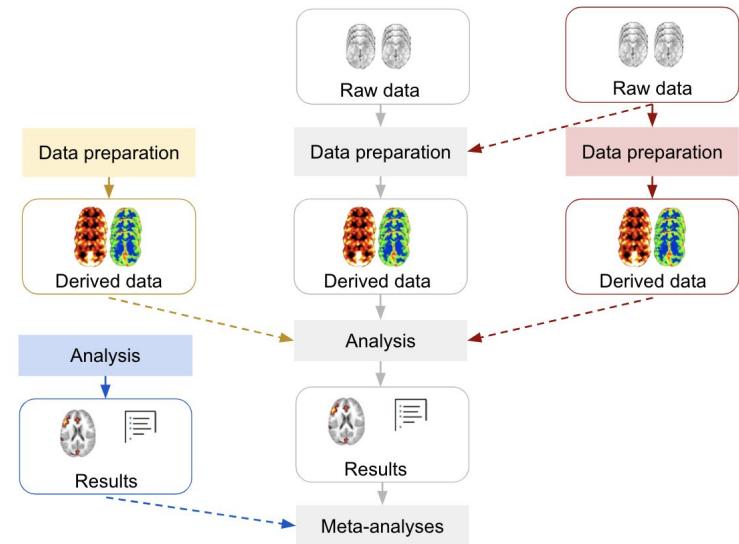
Levels of variability

- Variability in **single-lab** studies
 - Across subjects
 - Across scans



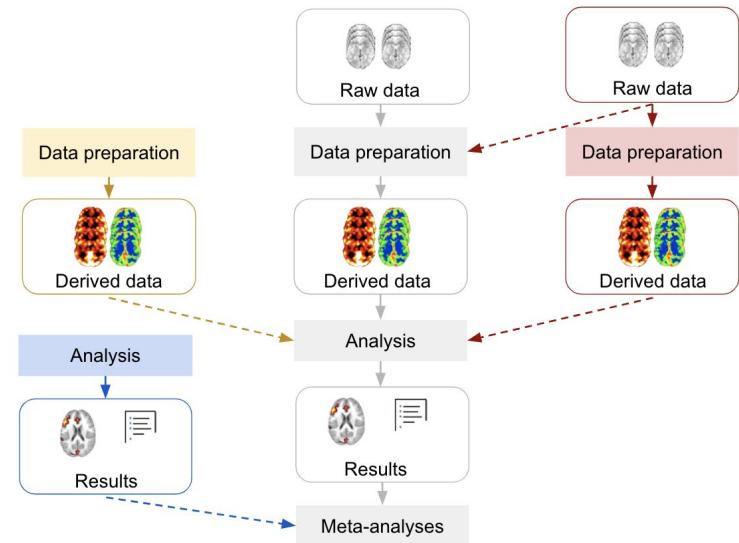
Levels of variability

- Variability in **single-lab** studies
 - Across subjects
 - Across scans
- Variability in **multi-lab** studies
 - All of the above plus
 - Across machines
 - Across sites
 - Across acquisition protocols



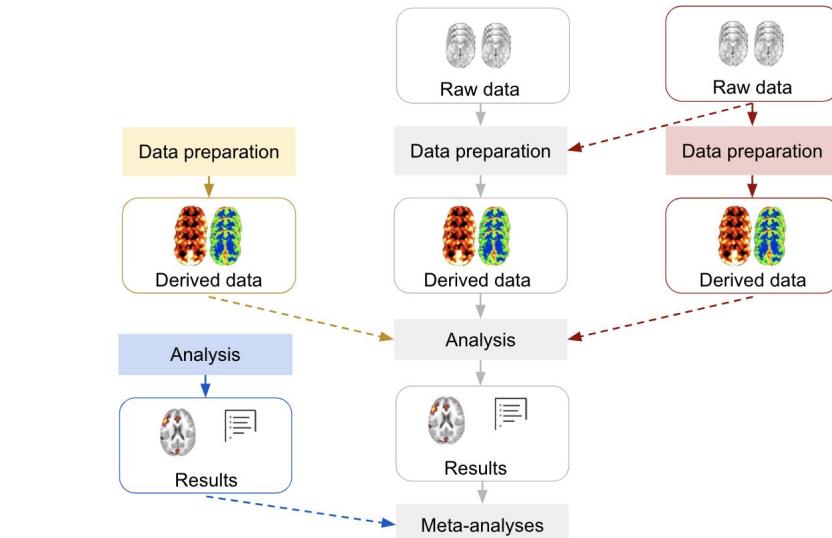
Levels of variability

- Variability in **single-lab** studies
 - Across subjects
 - Across scans
- Variability in **multi-lab** studies
 - All of the above plus
 - Across machines
 - Across sites
 - Across acquisition protocols
- Variability in **data integration** studies
 - All of the above plus
 - Across preparation protocols
 - Across analysis protocols



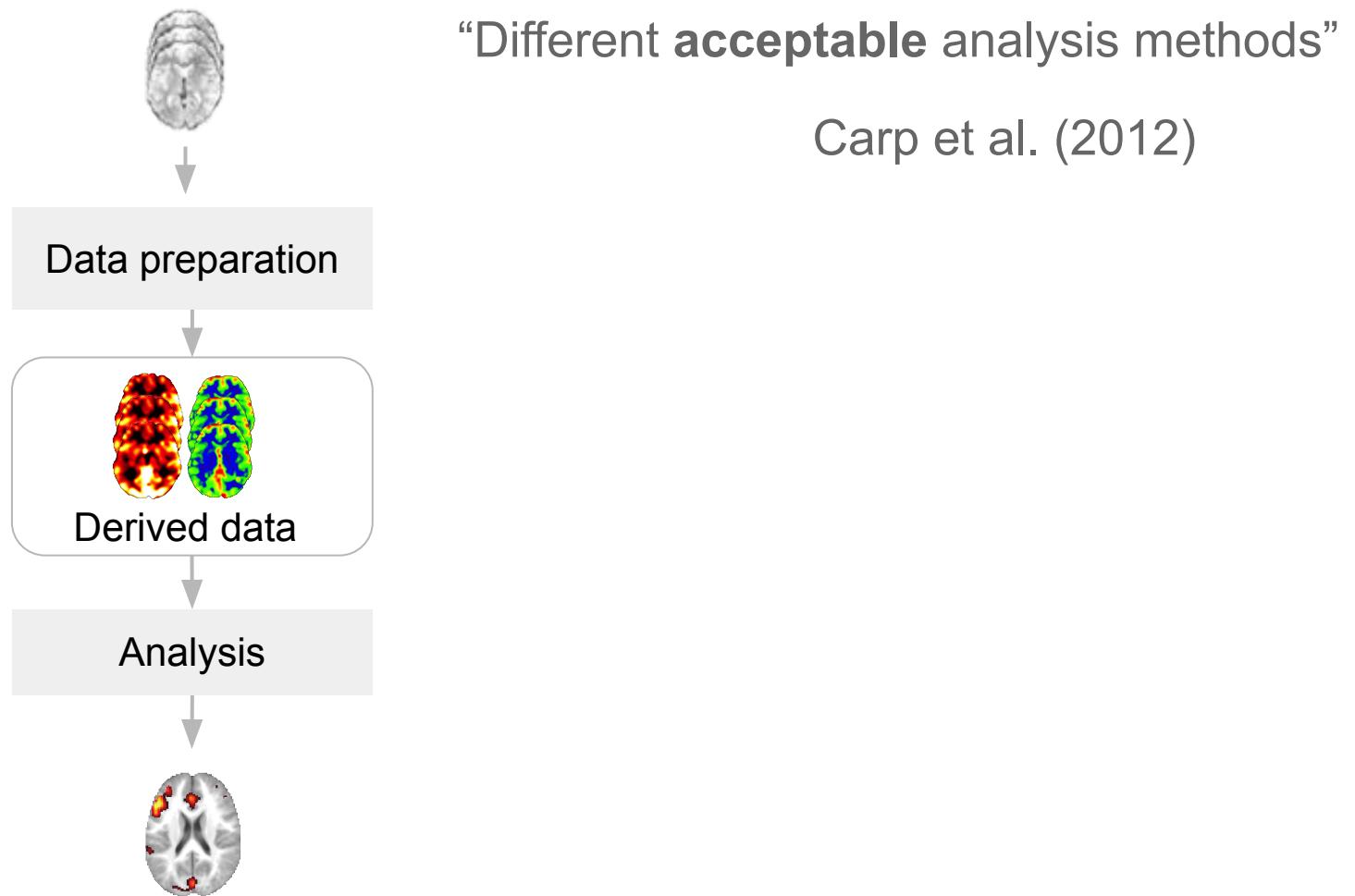
Levels of variability

- Variability in **single-lab** studies
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 - All of the above plus
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 - Across sites
 - Across acquisition protocols
- Variability in **data integration** studies
 - All of the above plus
 - Across preparation protocols
 - Across analysis protocols

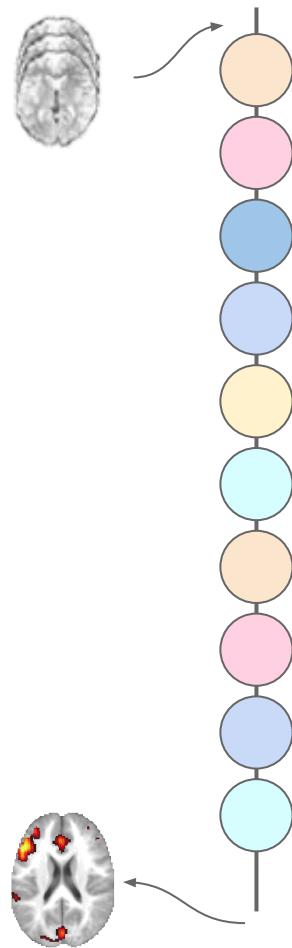


Analytic Variability

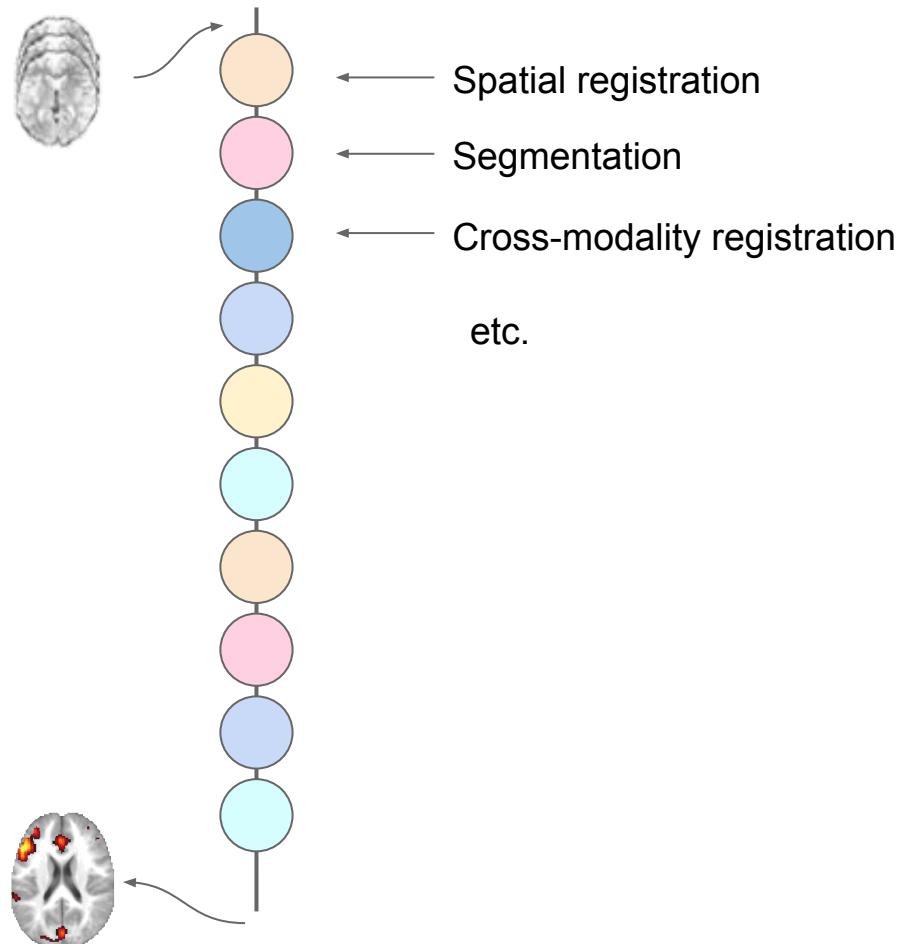
Analytic variability



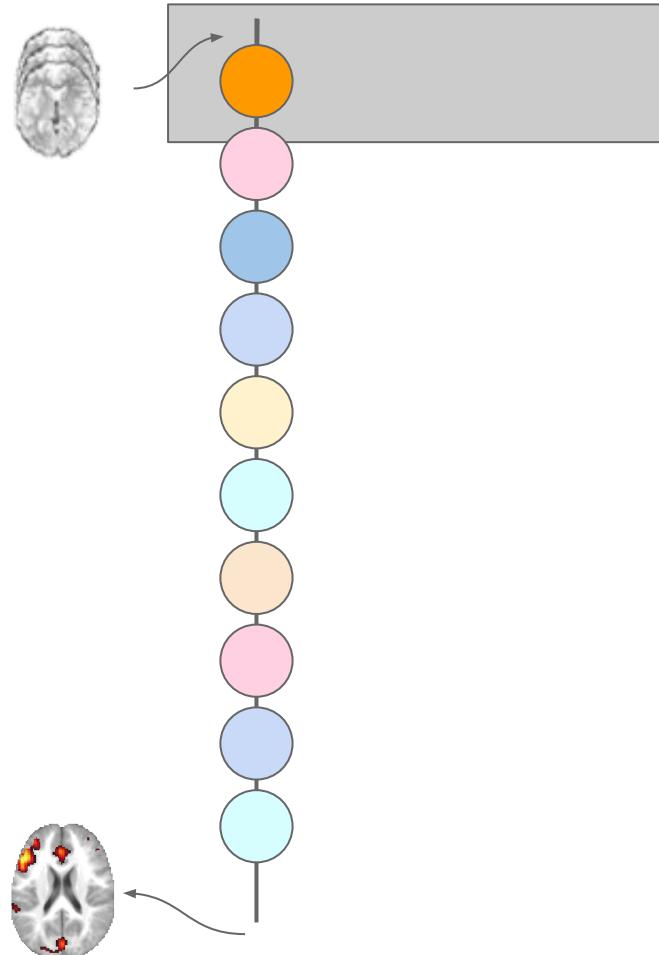
Analytic variability



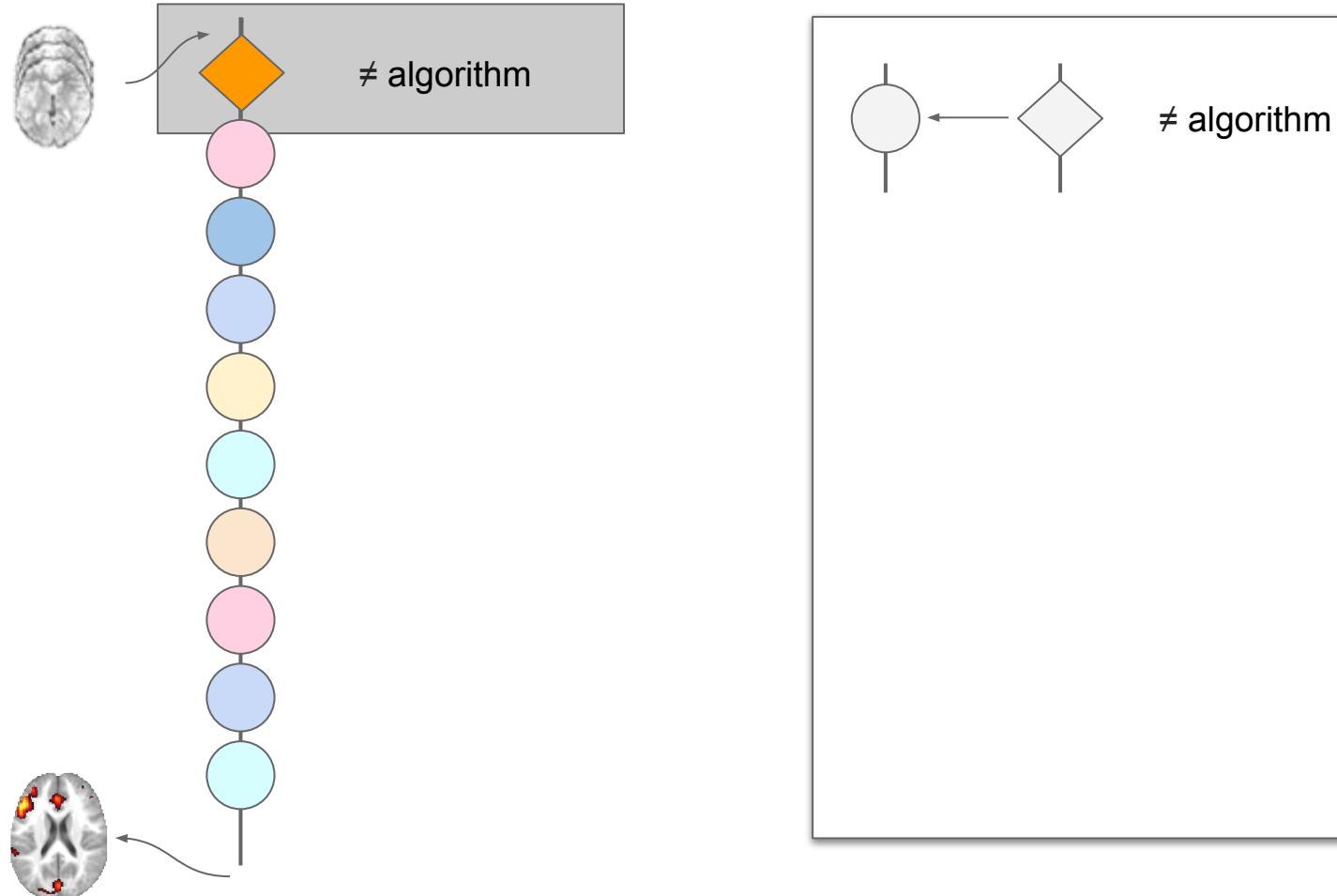
Analytic variability



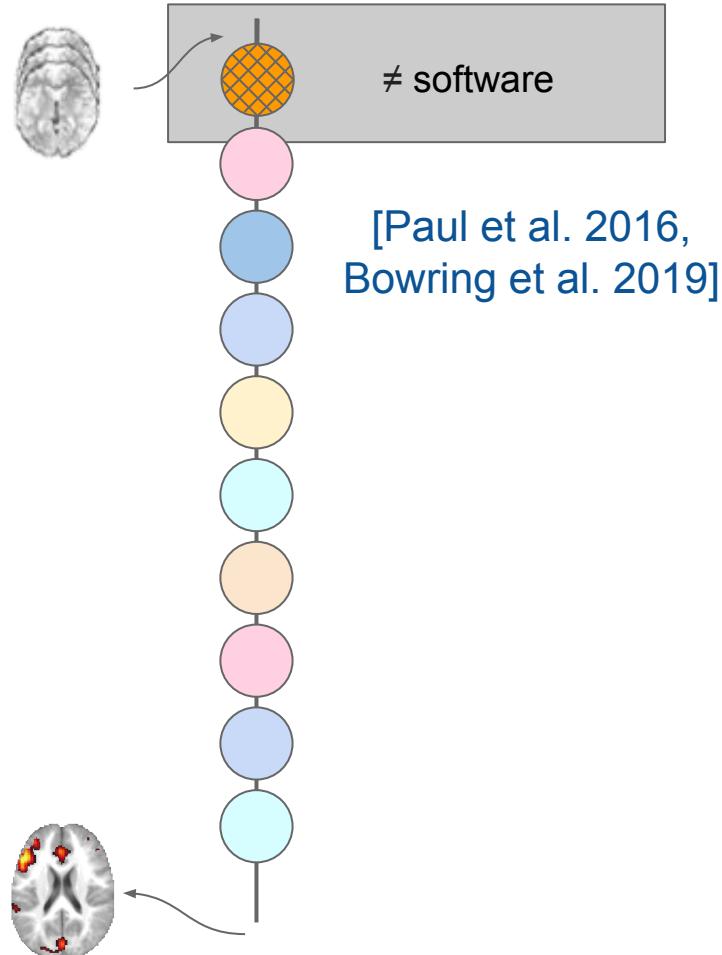
Analytic variability



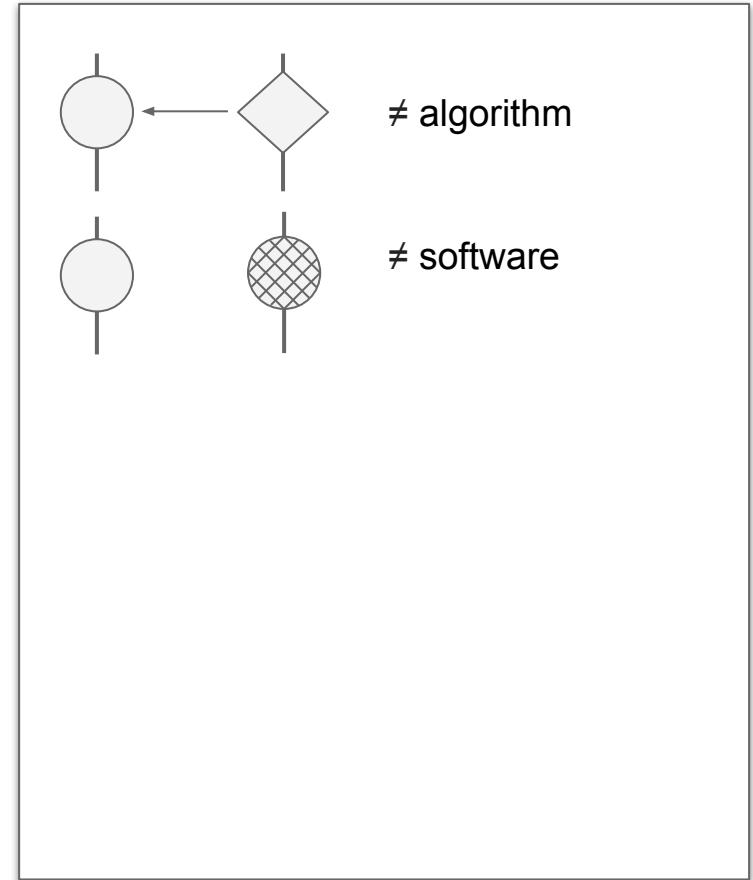
Analytic variability



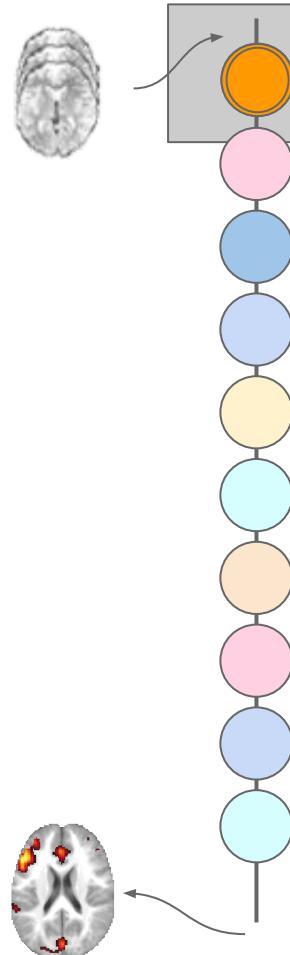
Analytic variability



[Paul et al. 2016,
Bowring et al. 2019]

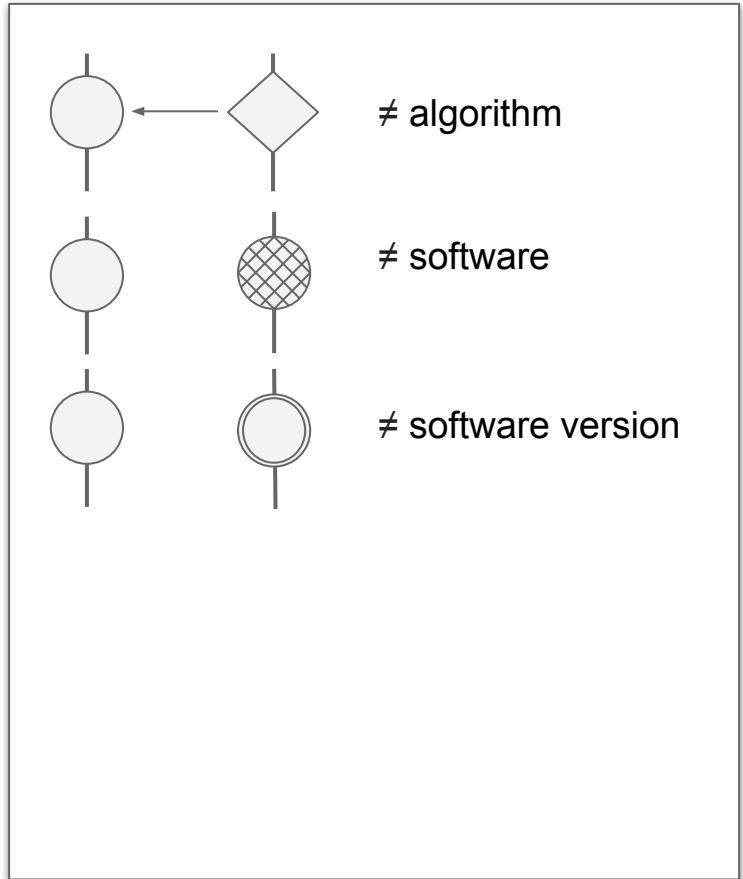


Analytic variability



≠ software
version

[Groenenschild et al. 2012]

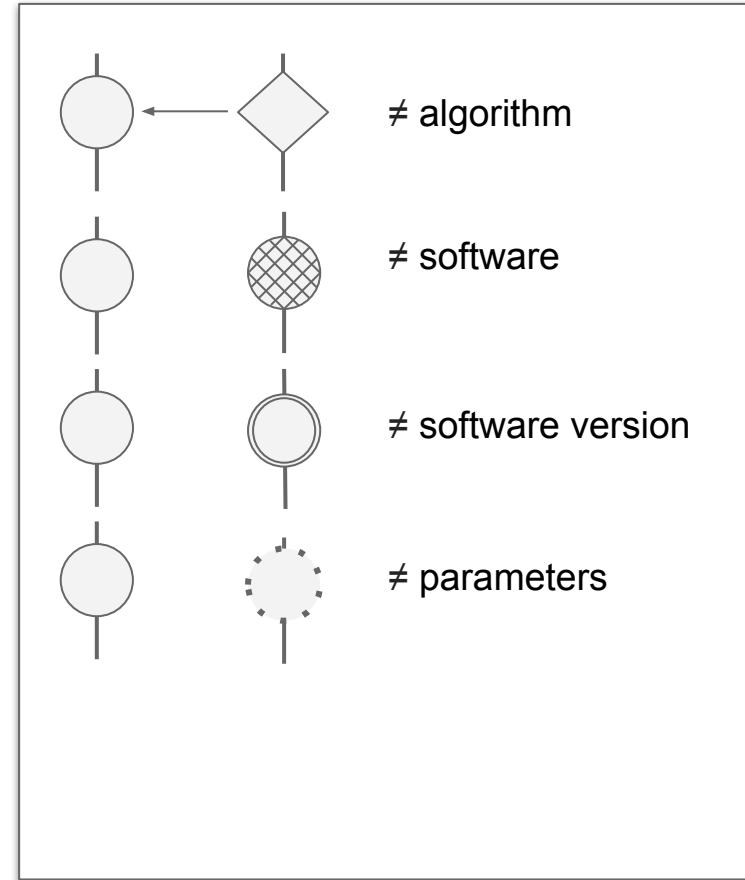
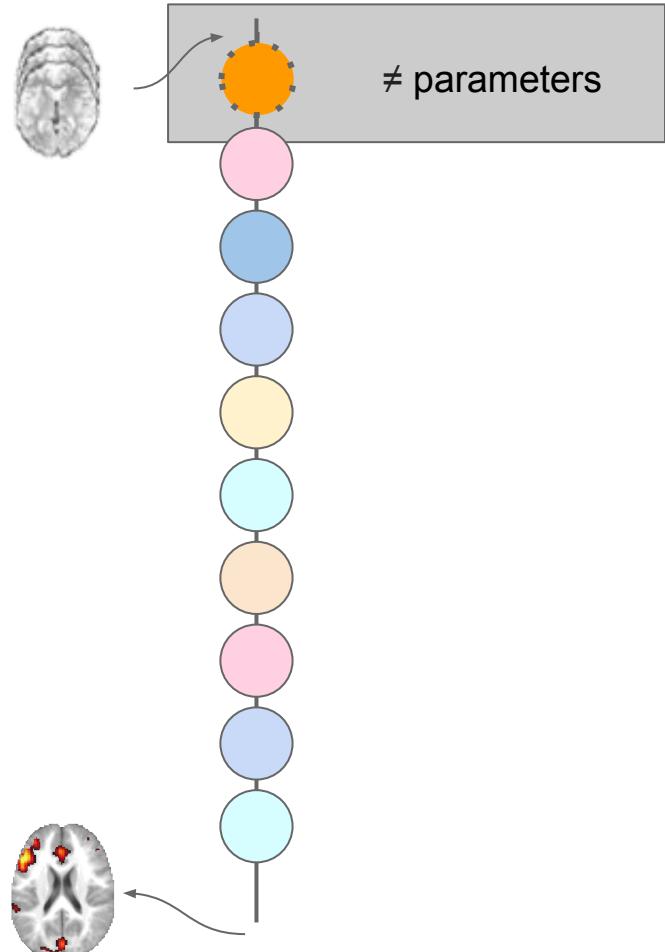


≠ algorithm

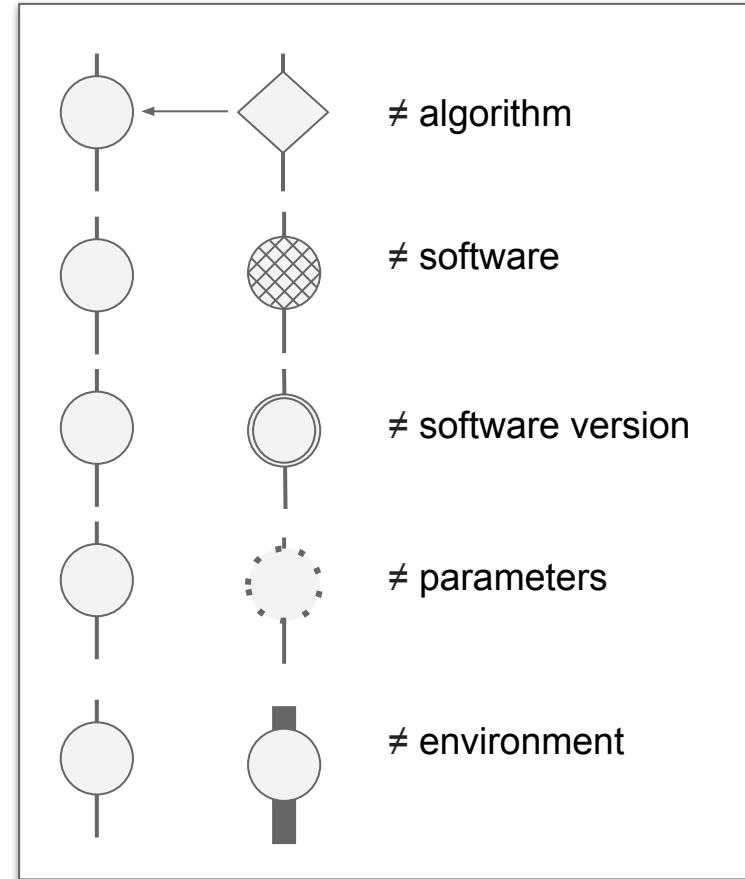
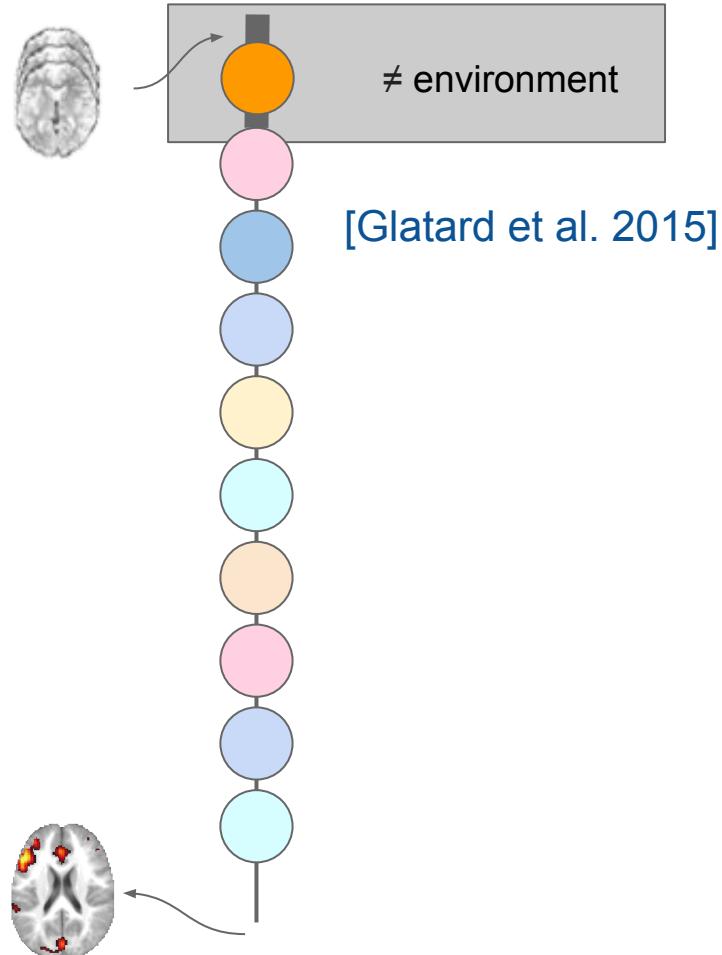
≠ software

≠ software version

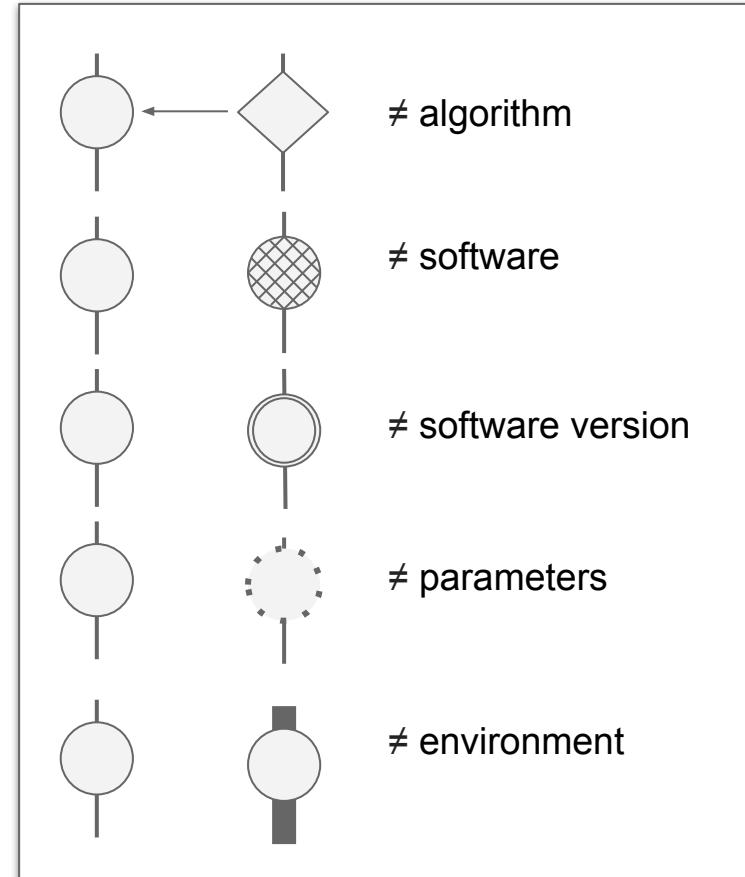
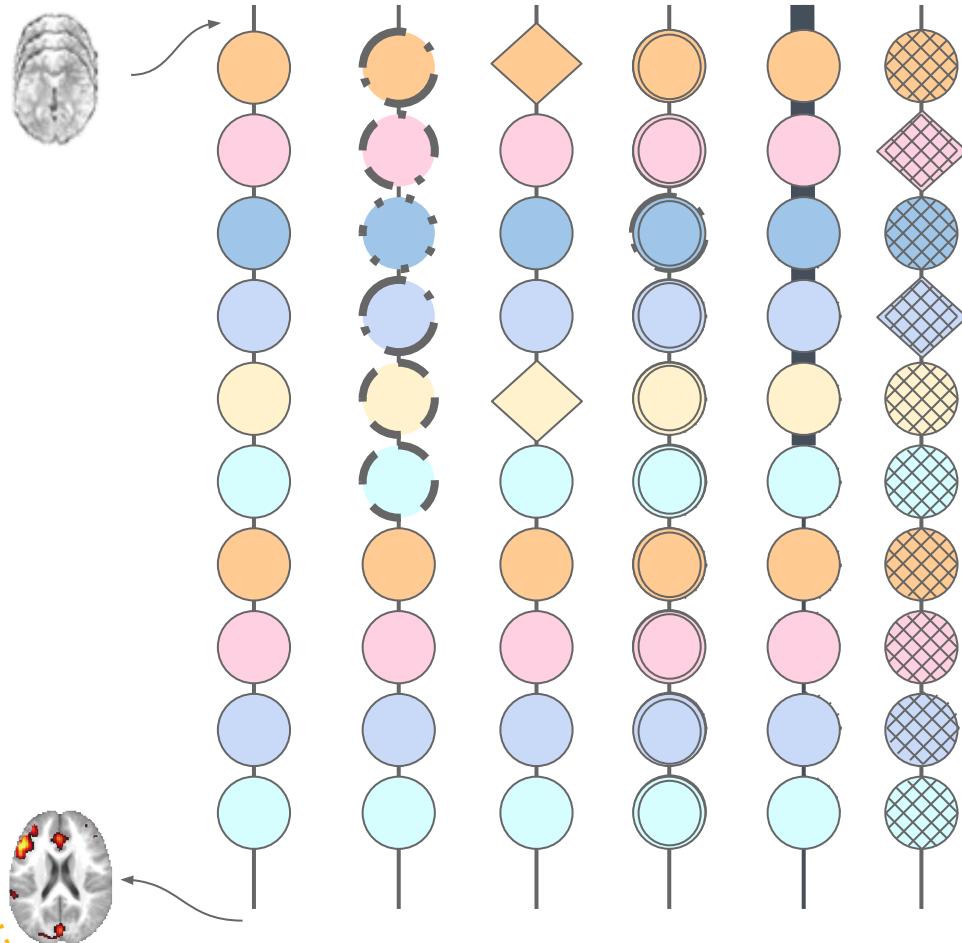
Analytic variability



Analytic variability

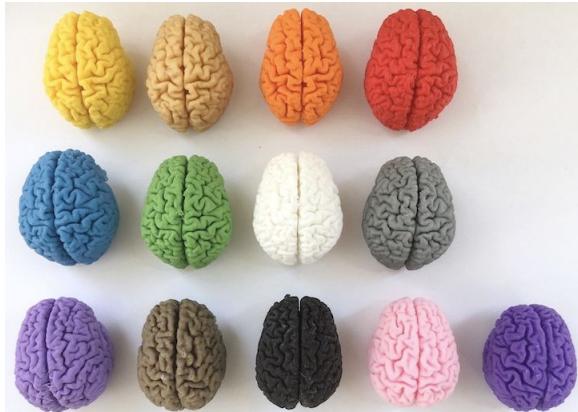


Analytic variability

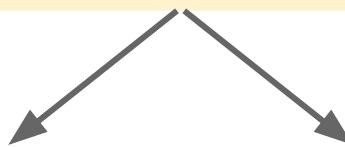


[Carp 2012; Nørgaard et al. 2019; Botvinik-Nezer 2020]

Towards data integration in brain imaging

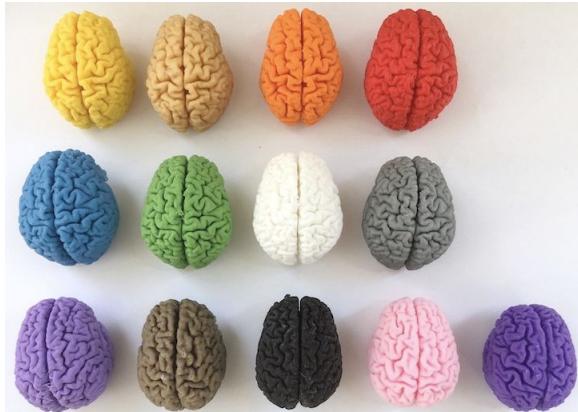


Towards **data integration**
in brain imaging studies

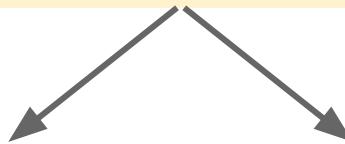


Standards for
data sharing

Statistical modelling
of analytic variability



Towards **data integration**
in brain imaging studies



Standards for
data sharing

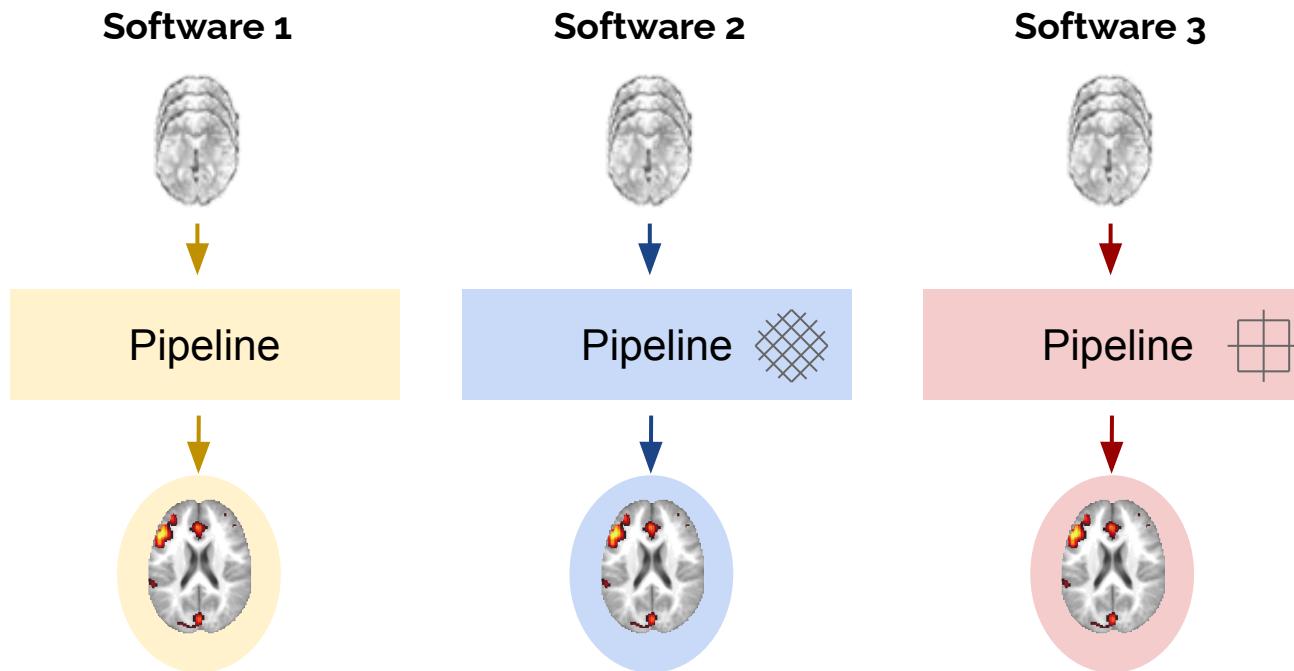
Statistical modelling
of analytic variability

Variations across software

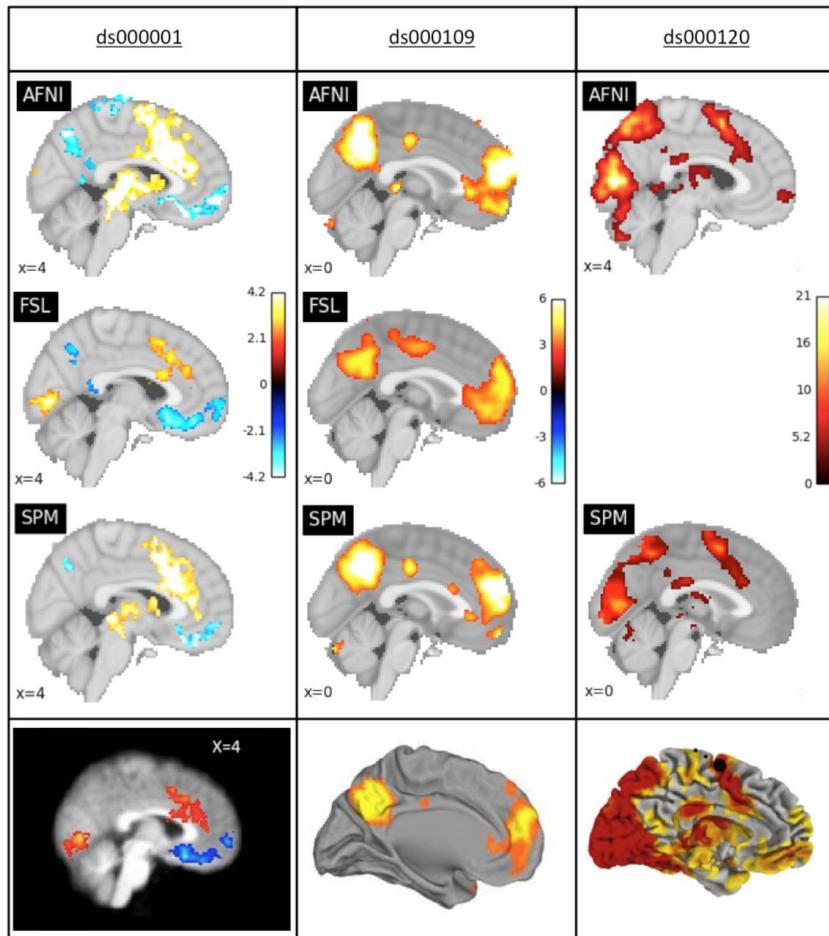
- Reproduced 3 published functional MRI studies
- Using 3 different software



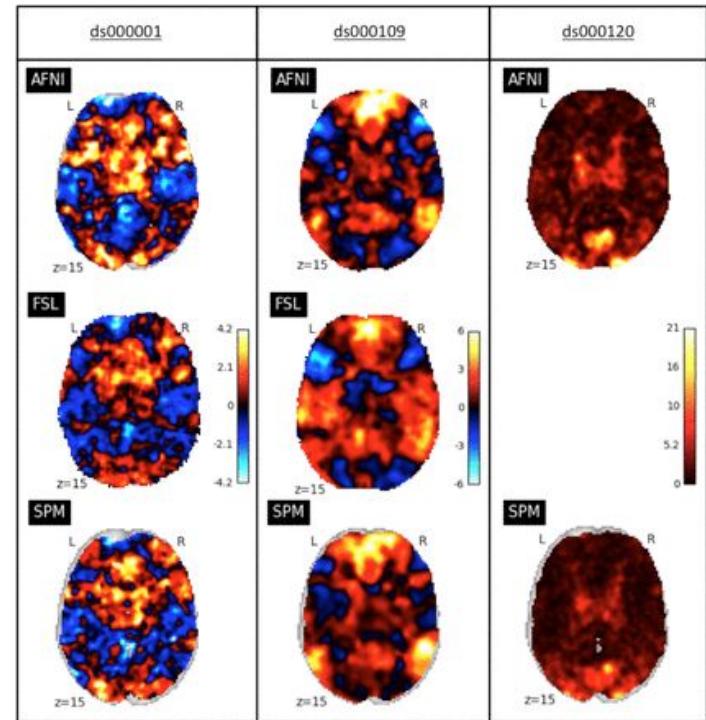
Alex Bowring Tom Nichols



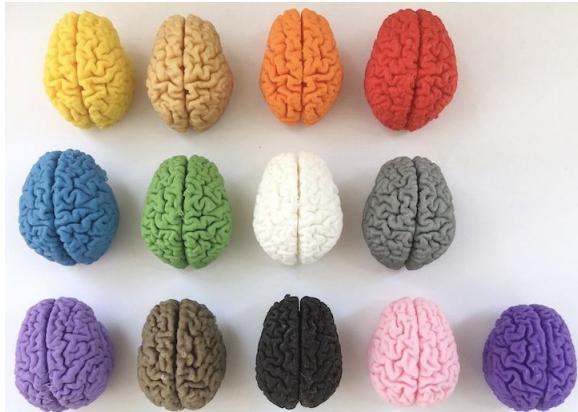
Variations across software



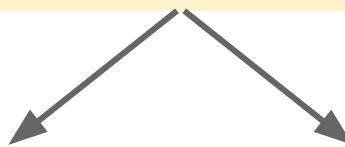
Comparison of the final results



Comparison of the statistic maps



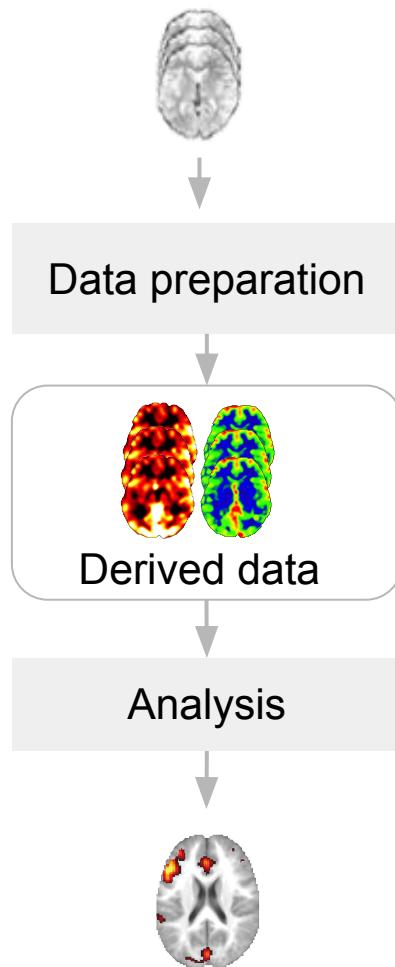
Towards **data integration**
in brain imaging studies



Standards for
data sharing

Statistical modelling
of analytic variability

Sharing more research outputs



Sharing more research outputs

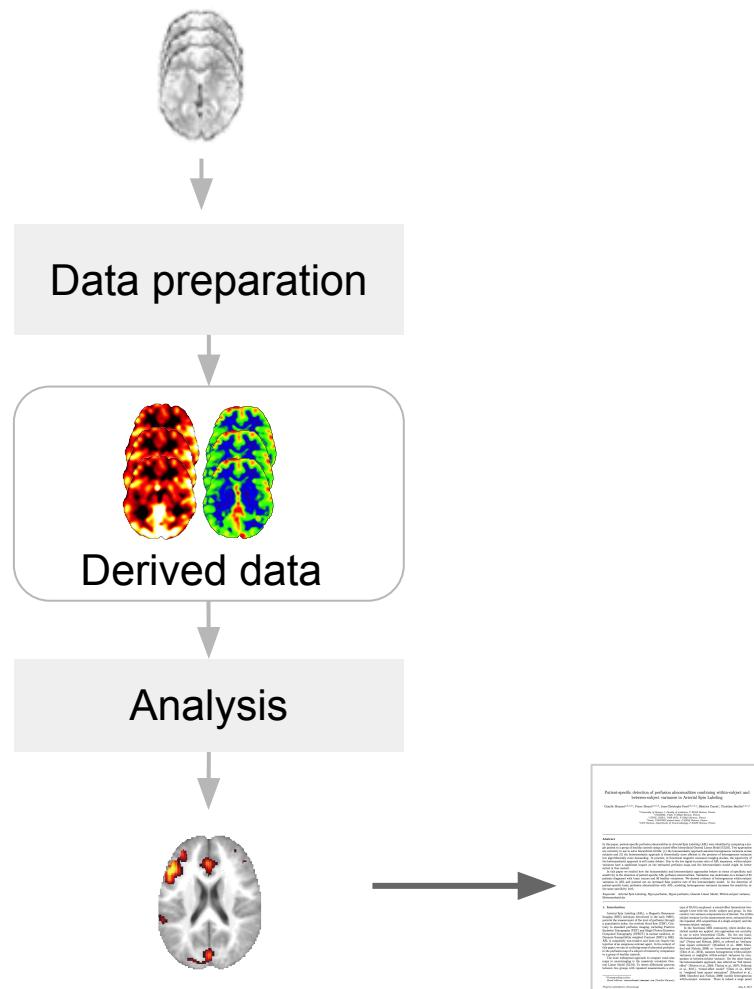


Image credits: [Parcels 1 2 & 4 \(CCo\)](#), [Parcel3 \(CCo\)](#), [Parcel5 \(CCo\)](#).

Sharing more research outputs

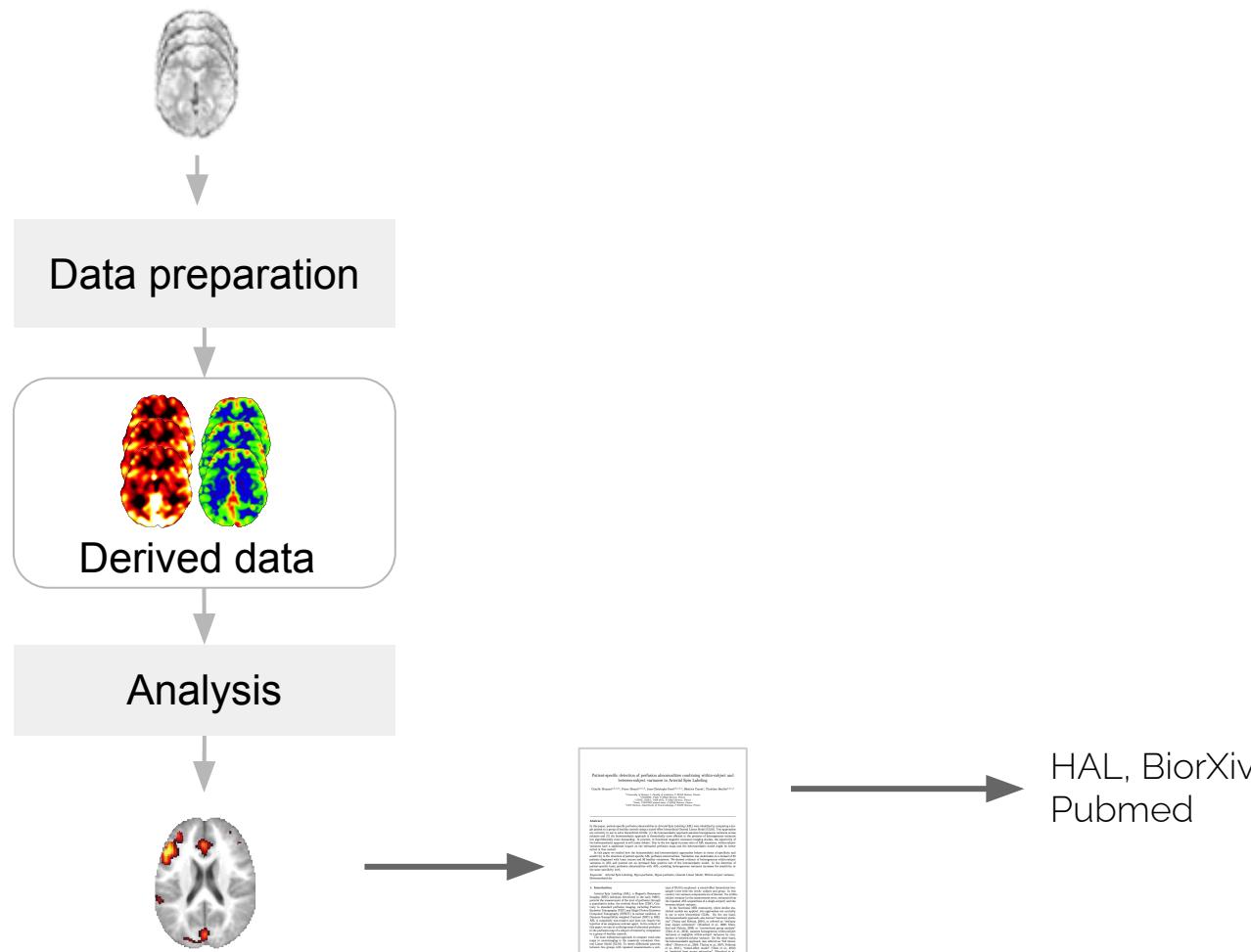


Image credits: [Parcels 1 2 & 4 \(CCo\)](#), [Parcel3 \(CCo\)](#), [Parcel5 \(CCo\)](#).

Sharing more research outputs

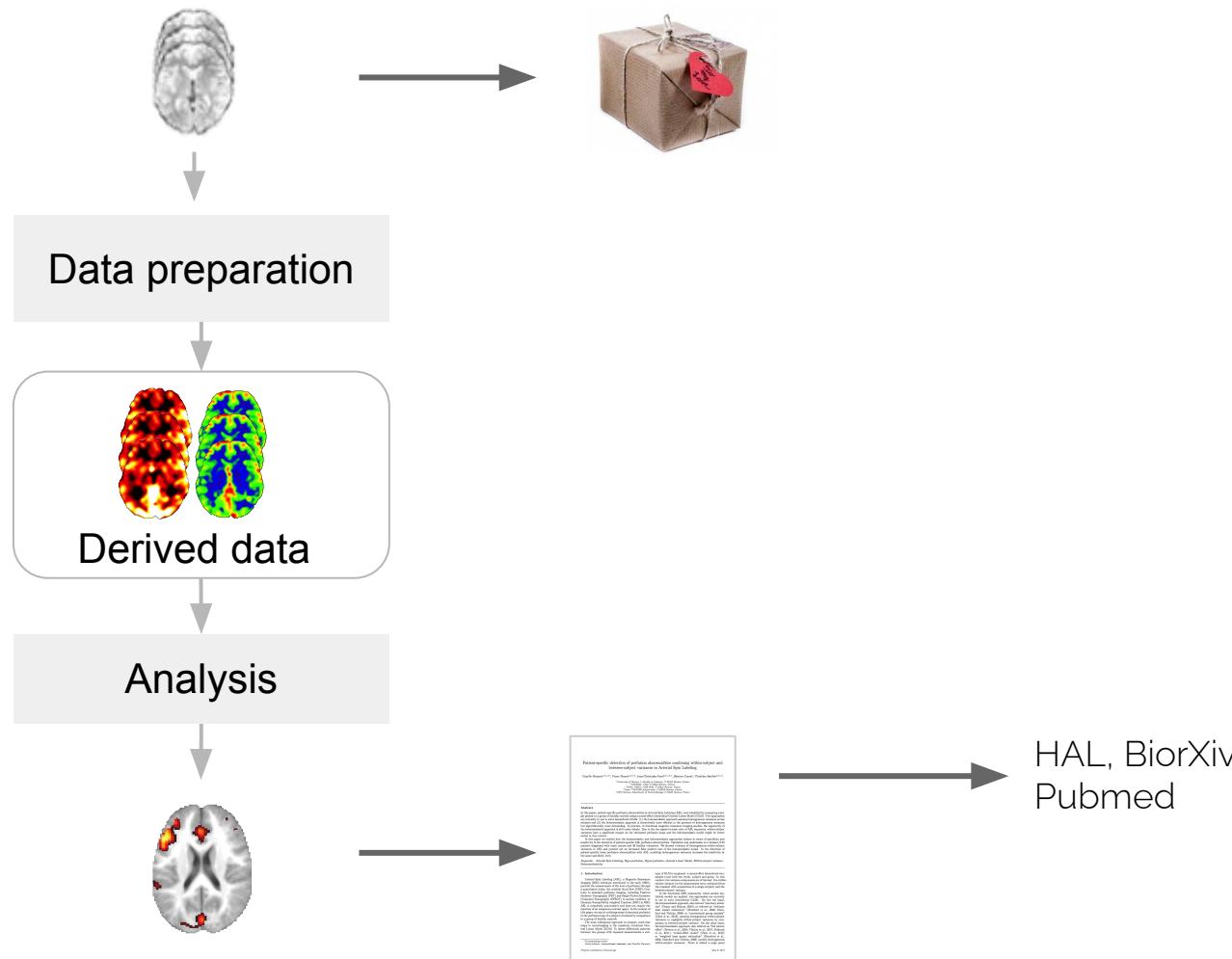


Image credits: [Parcels 1 2 & 4 \(CCo\)](#), [Parcel3 \(CCo\)](#), [Parcel5 \(CCo\)](#).

Brain Imaging Data Structure (BIDS)

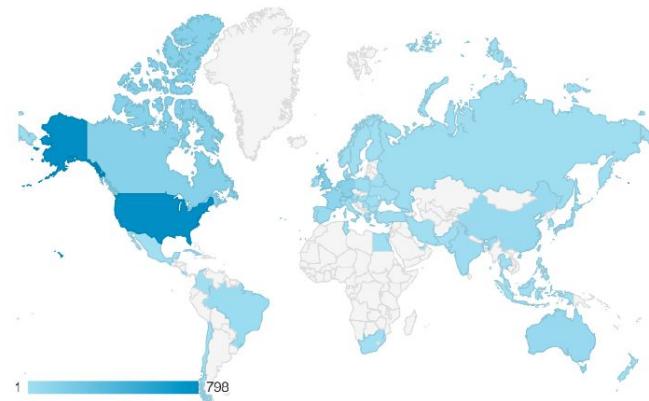
- Used in over 60 labs around the world
- Adopted by: FCP-INDI, Developing Human Connectome, SchizConnect and Donders Data repository.
- Extensions: MEG, iEEG, EEG



Krys
Gorgolewski

[Gorgolewski et al., Sci. Data 2016]

Traffic to bids.neuroimaging.io



Sharing more research outputs

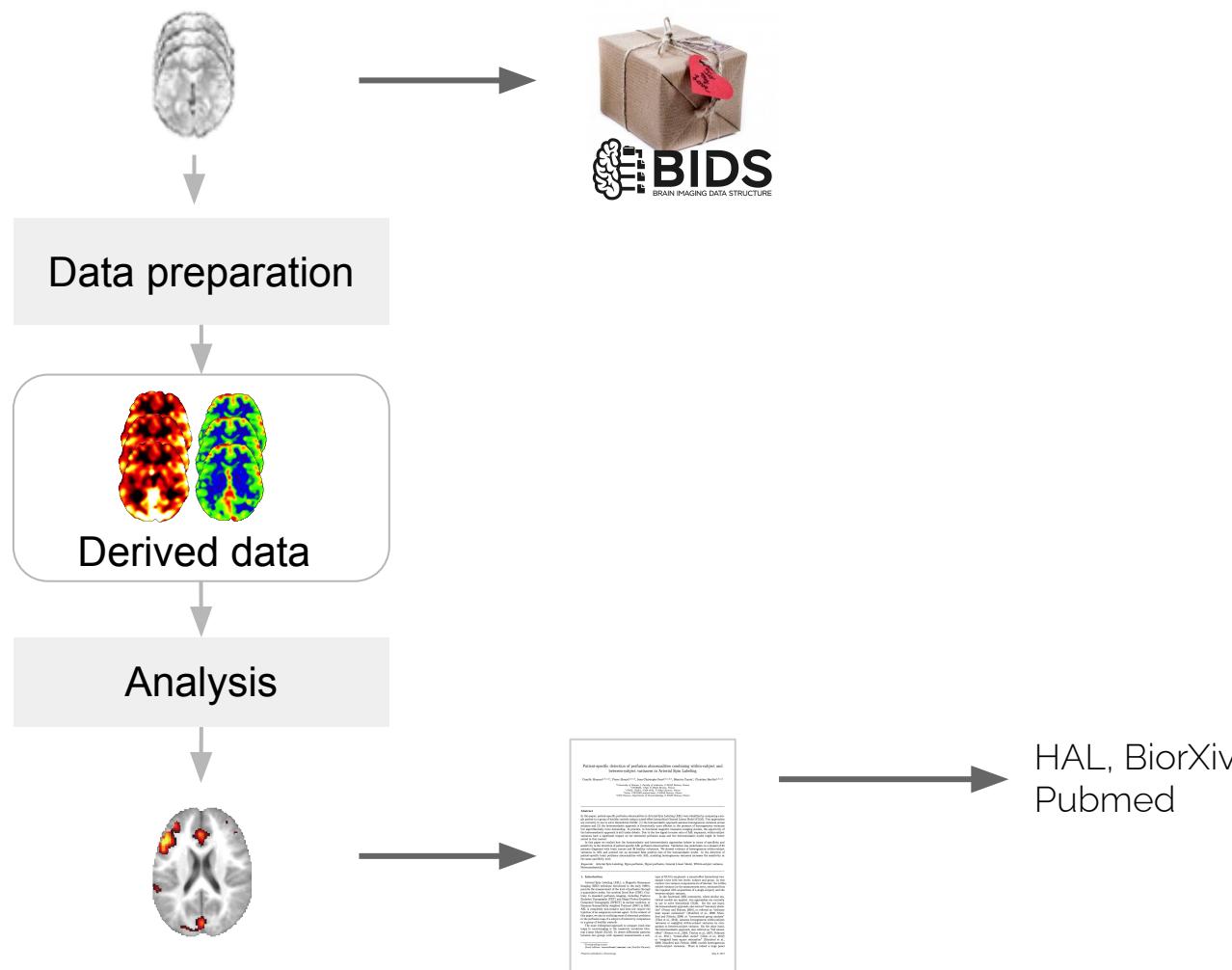


Image credits: [Parcels 1 2 & 4 \(CCo\)](#), [Parcel3 \(CCo\)](#), [Parcel5 \(CCo\)](#).

Sharing more research outputs

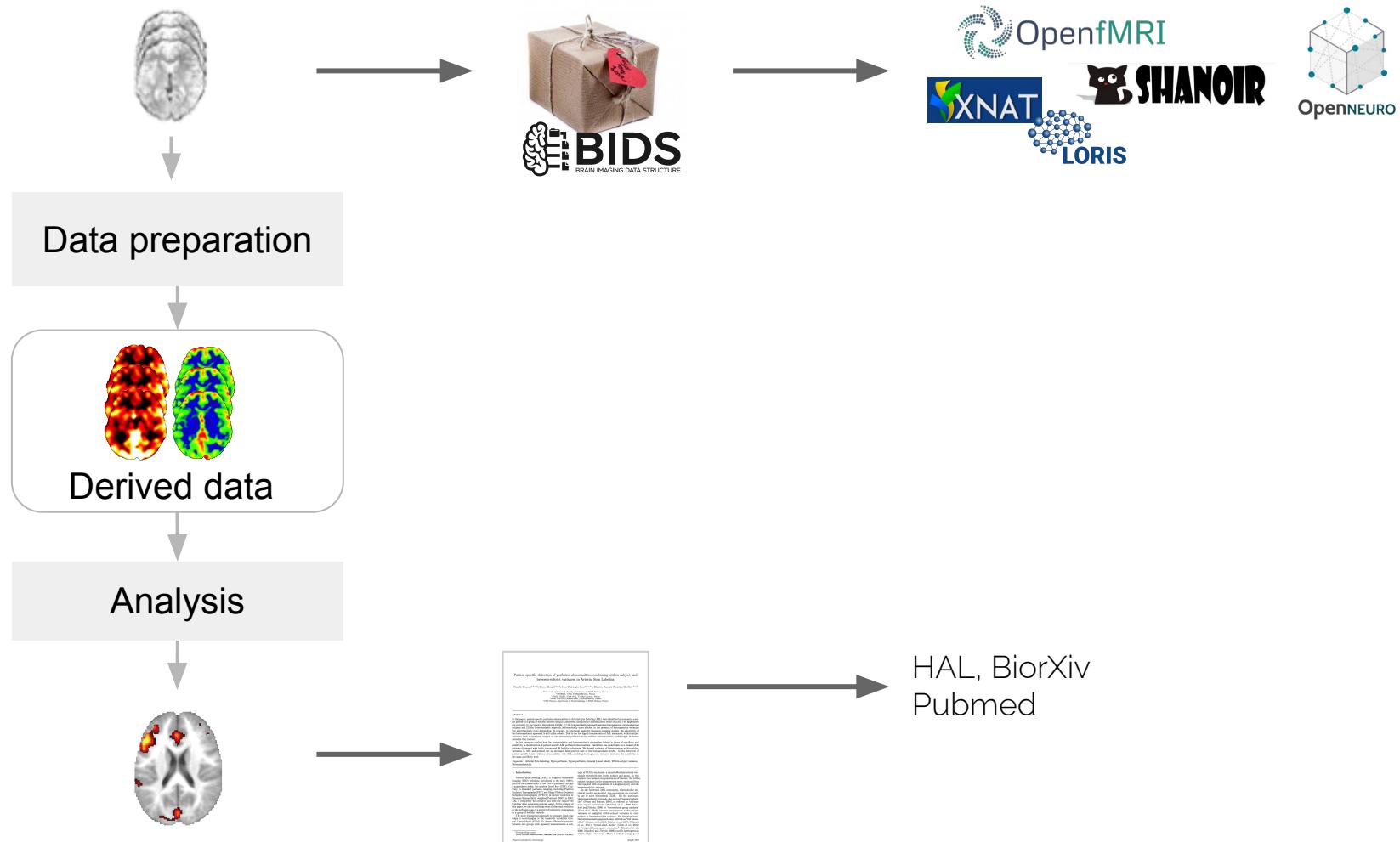
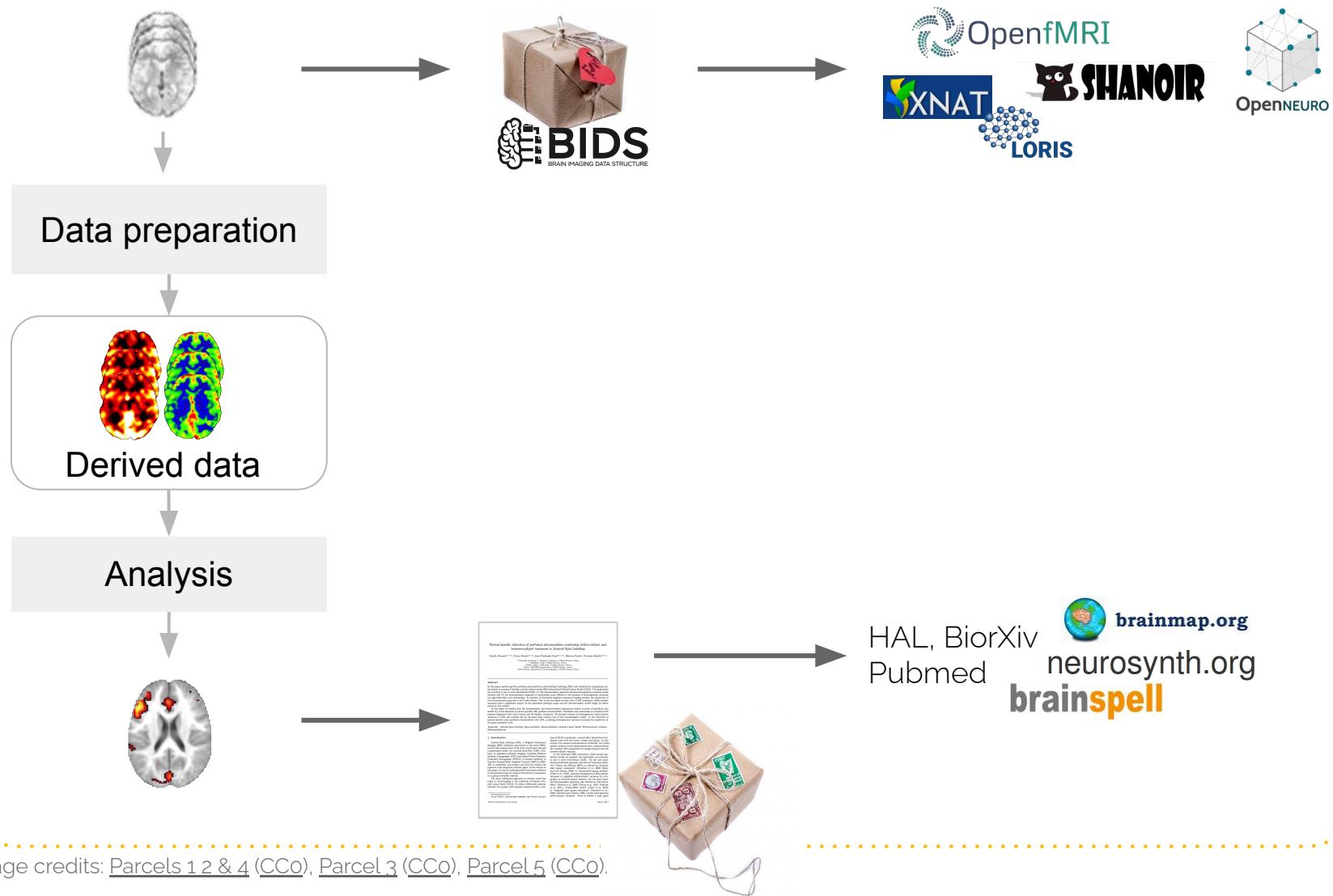


Image credits: [Parcels 1 2 & 4 \(CCo\)](#), [Parcel3 \(CCo\)](#), [Parcel5 \(CCo\)](#).

Sharing more research outputs

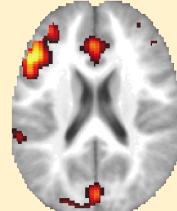


fMRI Results

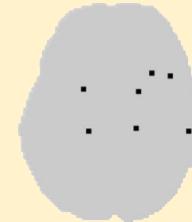
Publication



Figure
(selected slices)



Thresholded
statistics

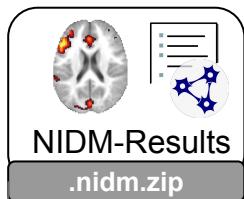


Peak locations



Incomplete statistical results
Ambiguous/incomplete methods
Metadata is not searchable

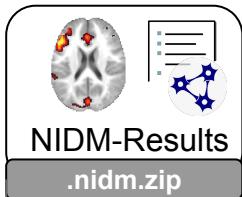
NIDM-Results pack



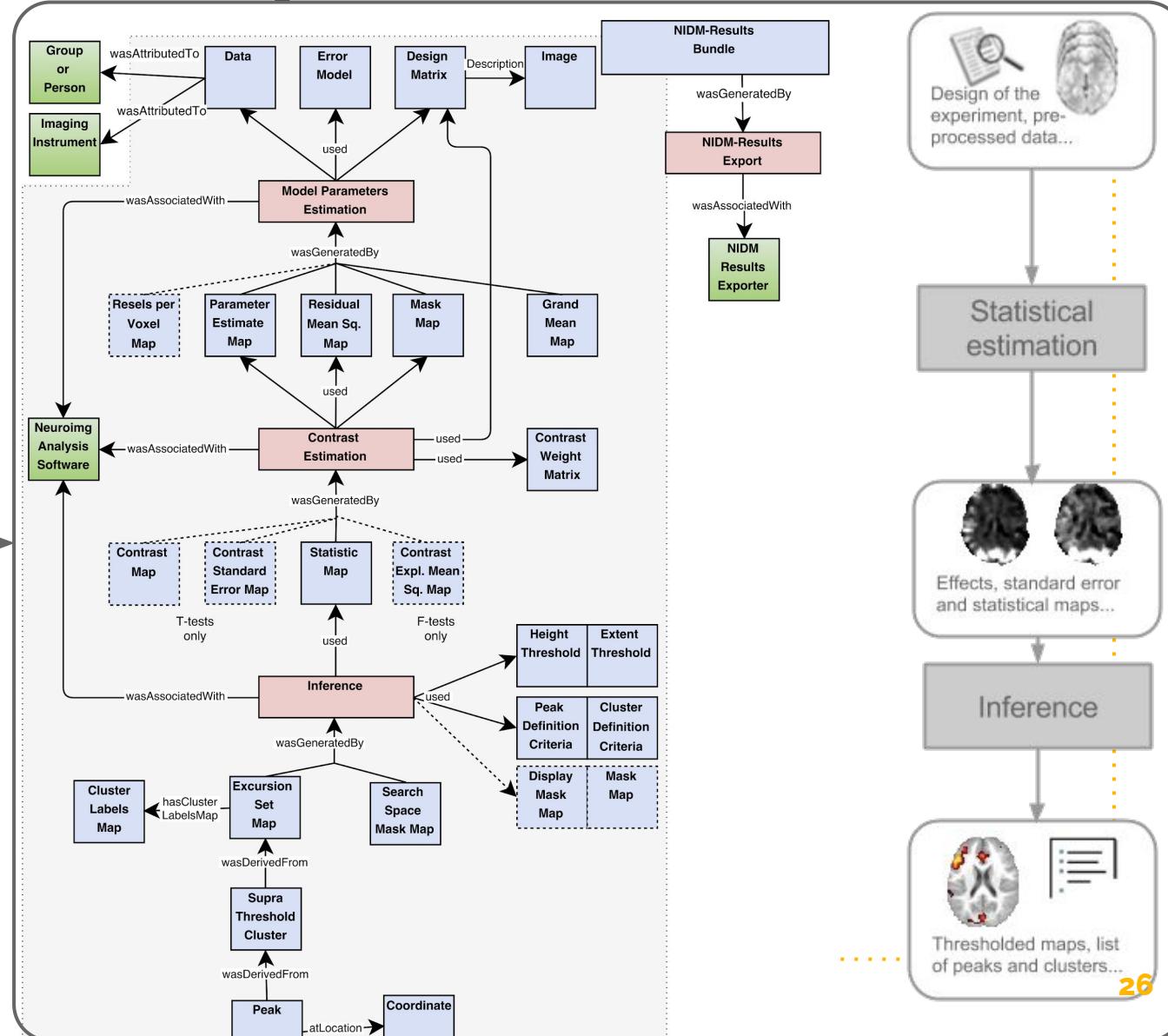
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- ContrastStandardError.nii.gz
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- DesignMatrix.png
- ExcursionSet.nii.gz
- ExcursionSet.png
- GrandMean.nii.gz
- Mask.nii.gz
- nidm.json
- nidm.ttl
- ParameterEstimate_001.nii.gz
- ParameterEstimate_002.nii.gz
- ResidualMeanSquares.nii.gz
- SearchSpaceMask.nii.gz
- TStatistic.nii.gz
- ZStatistic.nii.gz

[Maumet et al.,
Sci. Data 2016]

NIDM-Results pack

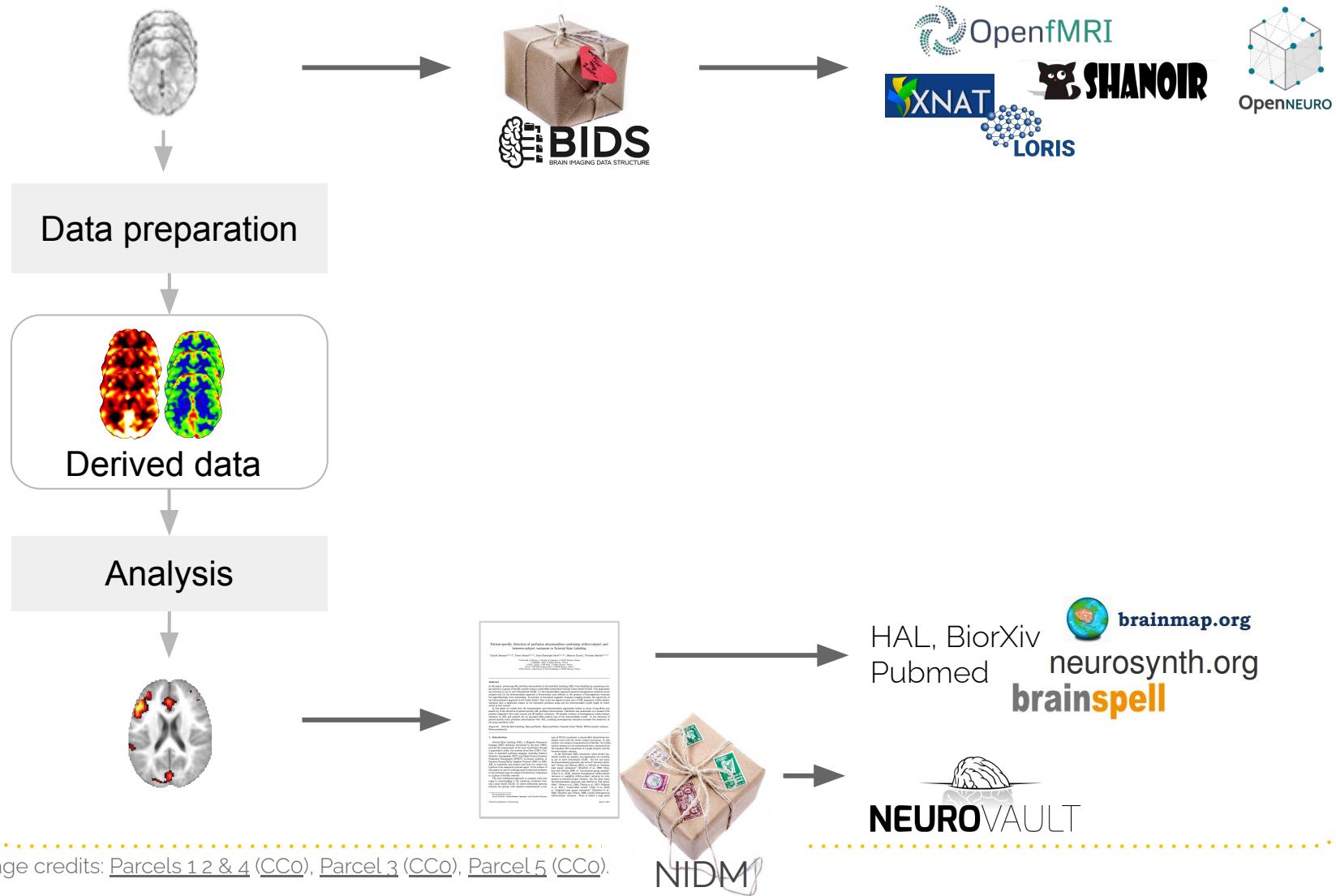


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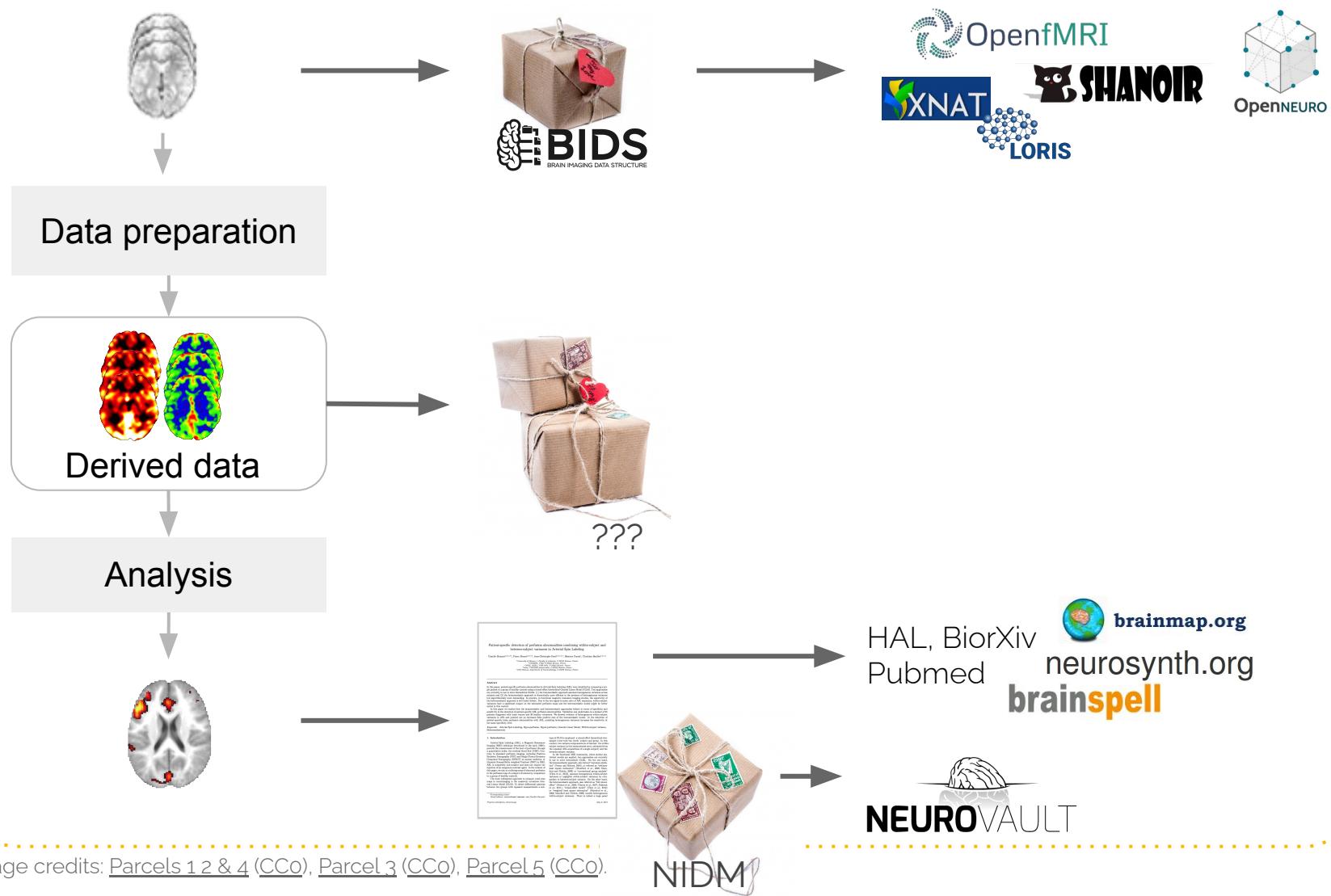


[Maumet et al.,
Sci. Data 2016]

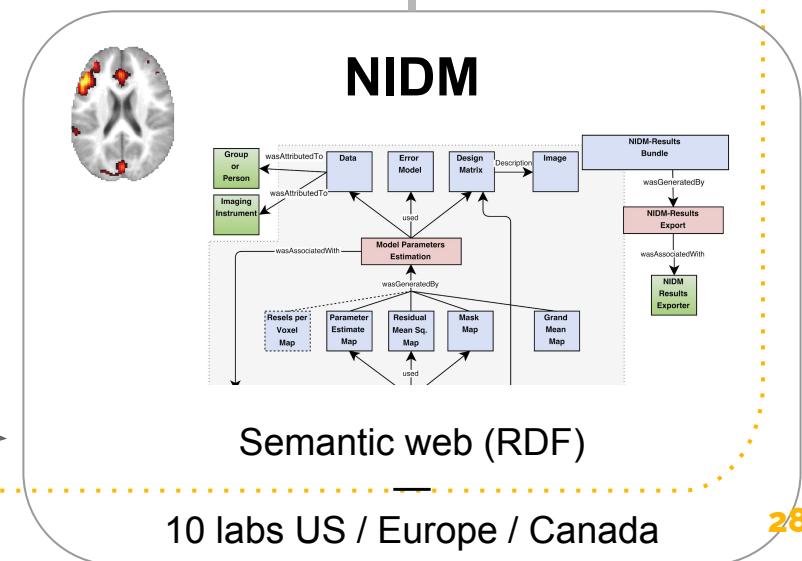
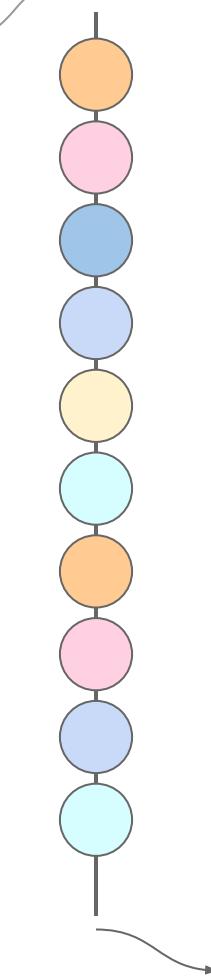
Sharing more research outputs



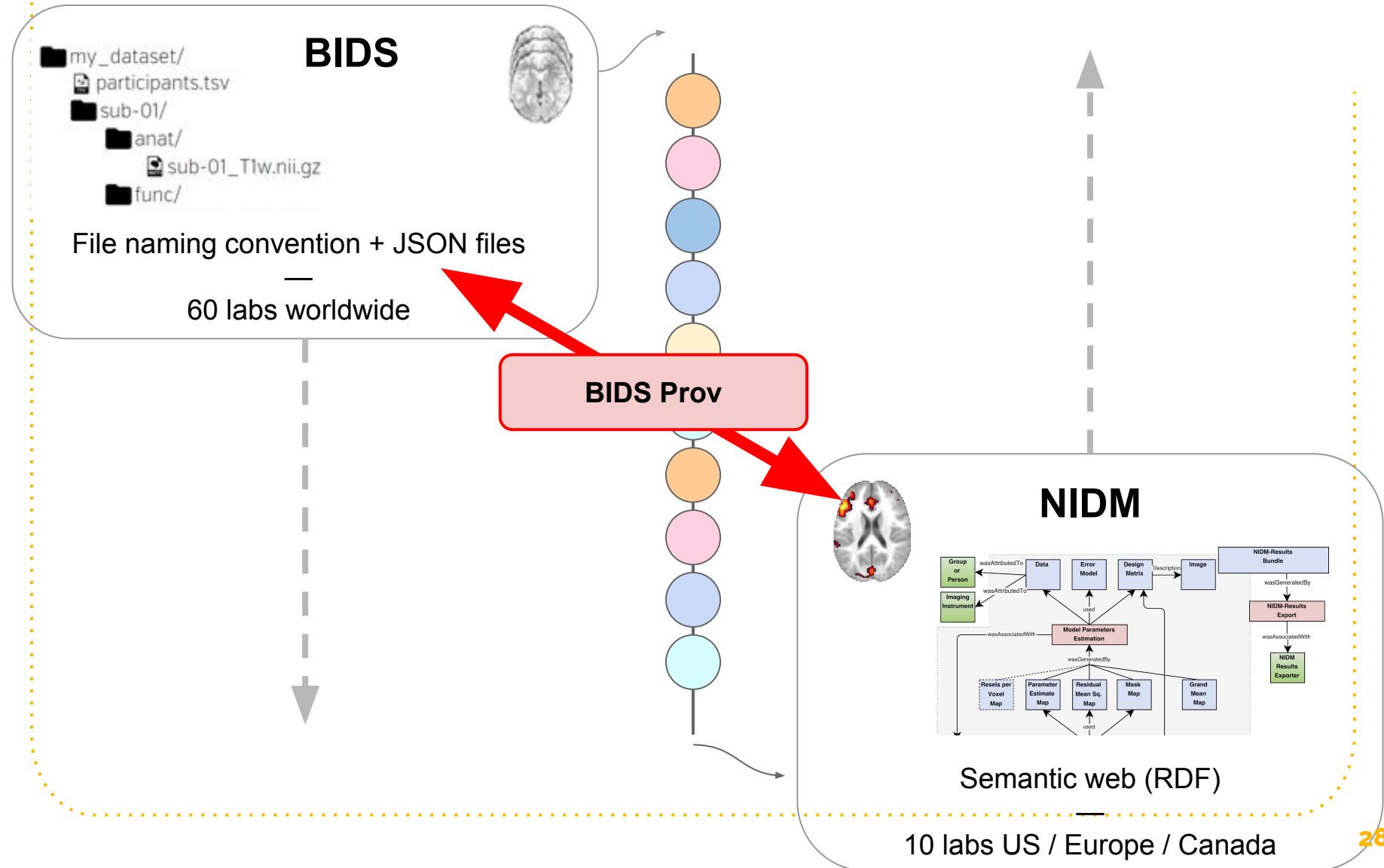
Sharing more research outputs

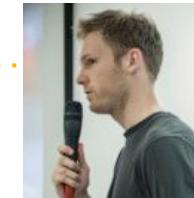


BIDS Prov Bridging BIDS & NIDM

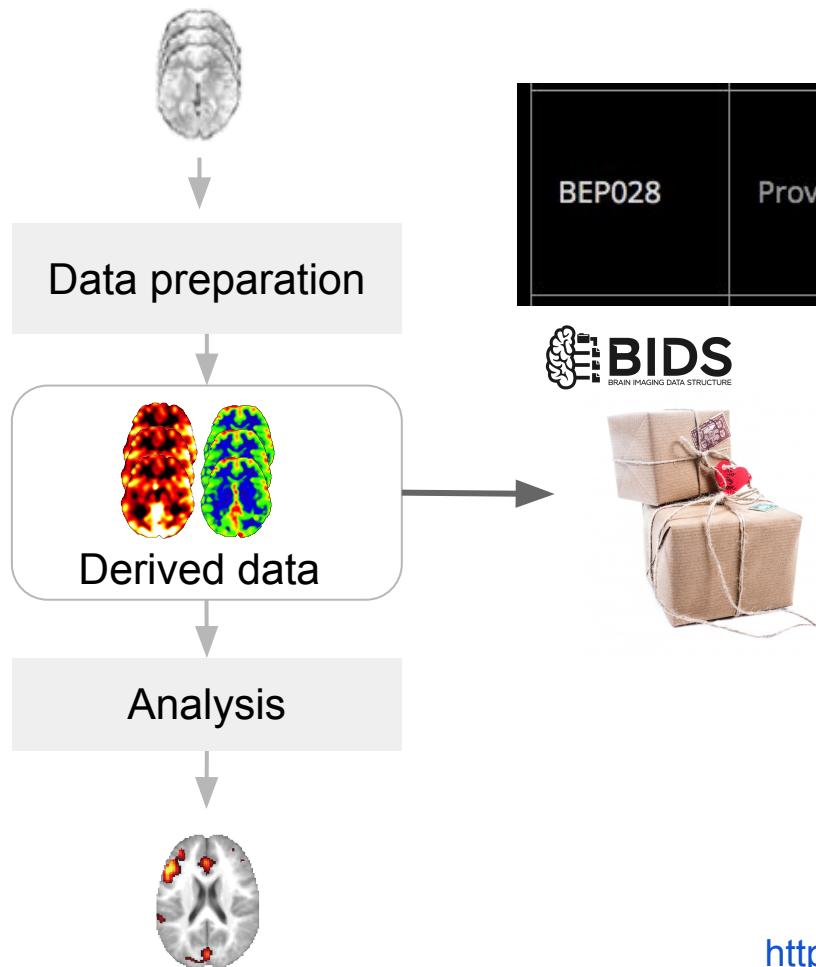


BIDS Prov Bridging BIDS & NIDM





BIDS Provenance



Satra
Ghosh

Rémi
Adon

BEP028	Provenance	Satra Ghosh and Camille Maumet	new BEP, actively looking for contributors and community input.
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Looking for
contributors and
community input

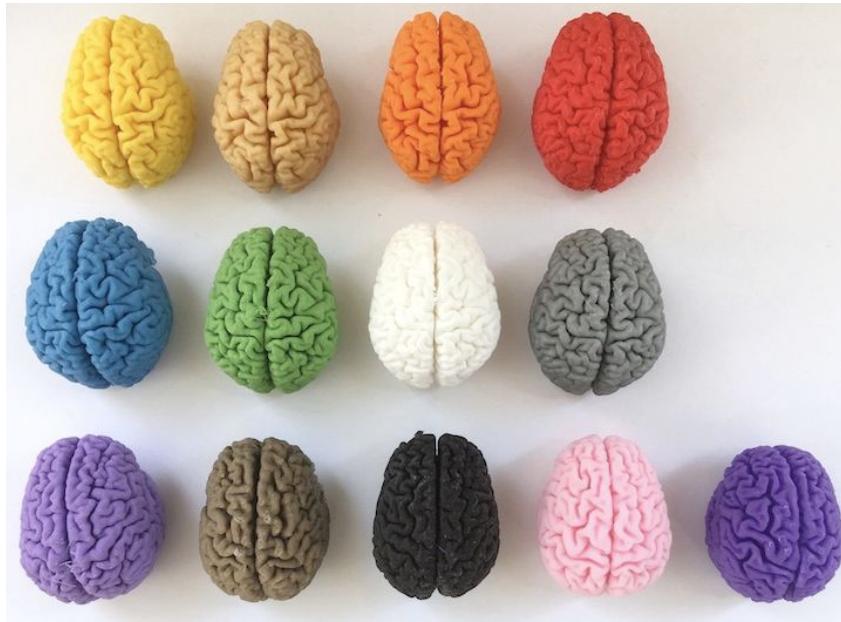
https://github.com/bids-standard/BEP028_BIDSProv

References

- Bowring**, A., Maumet*, C., & Nichols*, T. E. (2019). Exploring the impact of analysis software on task fMRI results. *Human Brain Mapping*, 0(0). <https://doi.org/10.1002/hbm.24603>
- Carp**, J. (2012). On the Plurality of (Methodological) Worlds: Estimating the Analytic Flexibility of fMRI Experiments. *Frontiers in Neuroscience*, 6. <https://doi.org/10.3389/fnins.2012.00149>
- Gorgolewski**, K. J., Auer, T., Calhoun, V. D., Craddock, R. C., Das, S., Duff, E. P., Flandin, G., Ghosh, S. S., Glatard, T., Halchenko, Y. O., Handwerker, D. A., Hanke, M., Keator, D., Li, X., Michael, Z., Maumet, C., Nichols, B. N., Nichols, T. E., Pellman, J., ... Poldrack, R. A. (2016). The brain imaging data structure, a format for organizing and describing outputs of neuroimaging experiments. *Scientific Data*, 3(1), 160044. <https://doi.org/10.1038/sdata.2016.44>
- Maumet**, C., Auer, T., Bowring, A., Chen, G., Das, S., Flandin, G., Ghosh, S., Glatard, T., Gorgolewski, K. J., Helmer, K. G., Jenkinson, M., Keator, D. B., Nichols, B. N., Poline, J.-B., Reynolds, R., Sochat, V., Turner, J., & Nichols, T. E. (2016). Sharing brain mapping statistical results with the neuroimaging data model. *Scientific Data*, 3, 160102. <https://doi.org/10.1038/sdata.2016.102>
- Poldrack**, R. A., Baker, C. I., Durnez, J., Gorgolewski, K. J., Matthews, P. M., Munafò, M. R., Nichols, T. E., Poline, J.-B., Vul, E., & Yarkoni, T. (2017). Scanning the horizon: Towards transparent and reproducible neuroimaging research. *Nature Reviews Neuroscience*, 18(2), 115–126. <https://doi.org/10.1038/nrn.2016.167>

Towards **large-scale** brain imaging studies

Camille Maumet



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Thank you!

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