



NIDM-Results: a model to share brain mapping statistical results

Camille Maumet

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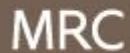
Submitted on 4 Oct 2018

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Cognition and
Brain Sciences Unit



NIDM-Results: a model to share brain mapping statistical results

CBU Open Science Workshop 2016, Nov. 22nd

Camille Maumet

Neuroimaging Statistics, University of Warwick, UK

Agenda

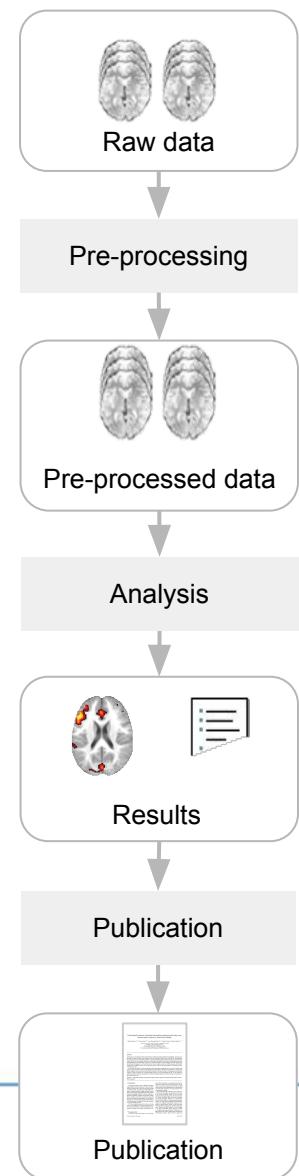
- Background
 - Reporting of neuroimaging results
 - Neuroimaging meta-analyses
- The NeuroImaging Data Model
- Example of image-based meta-analysis



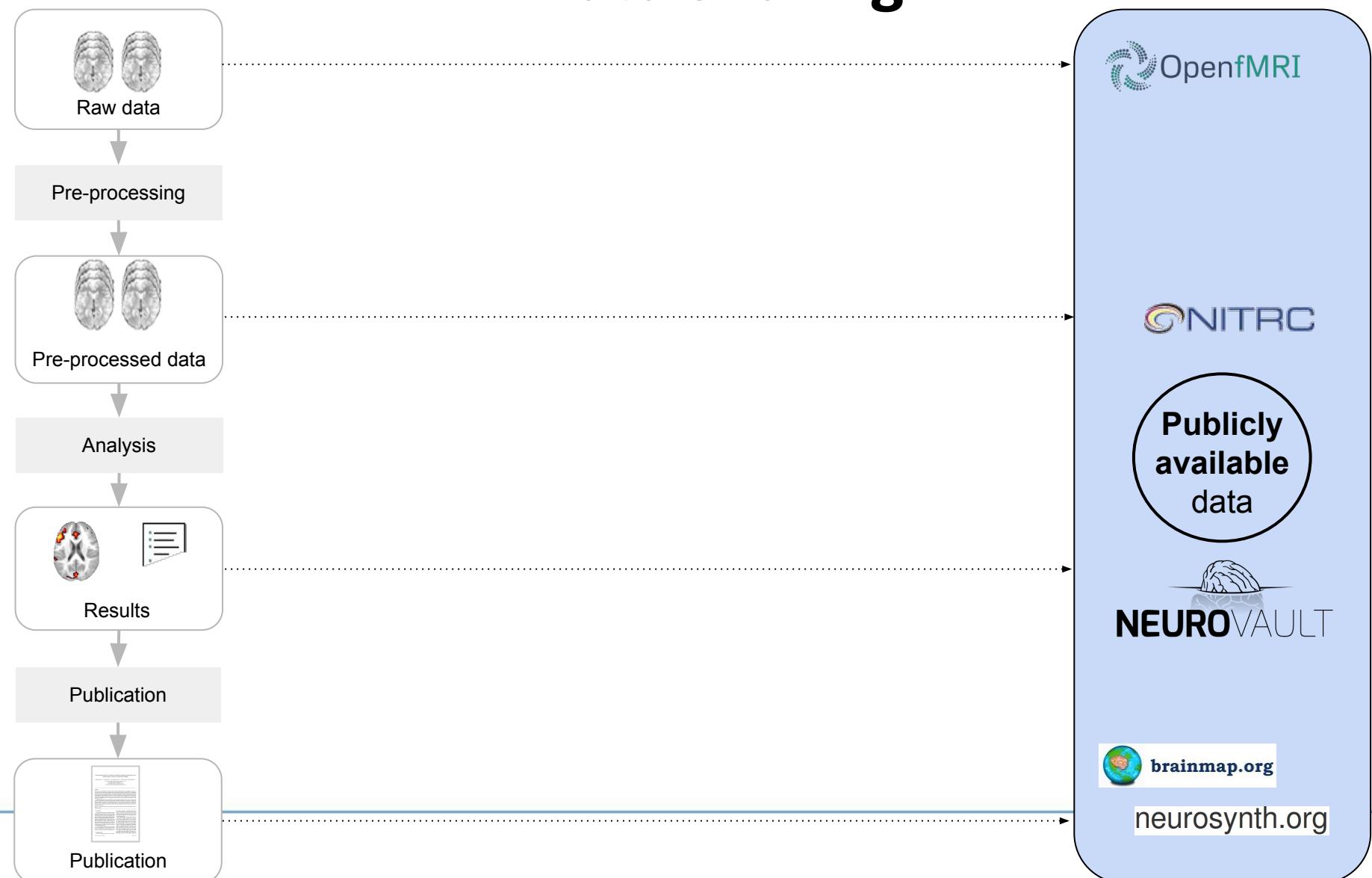
Background

Reporting of neuroimaging results

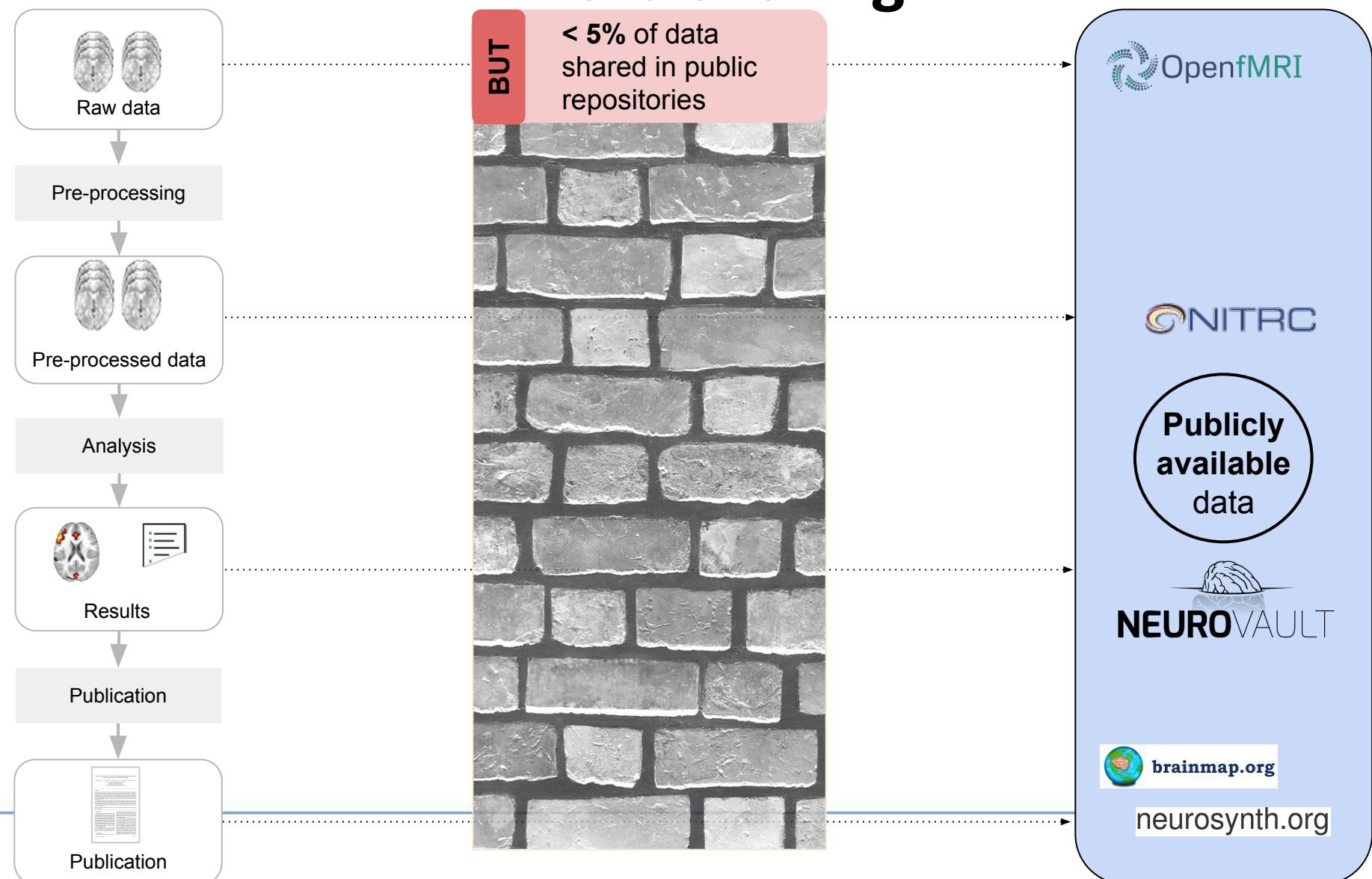
Data sharing



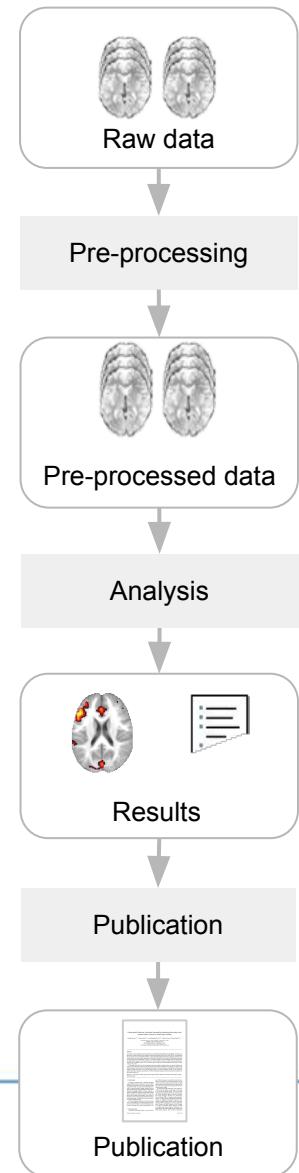
Data sharing



Data sharing

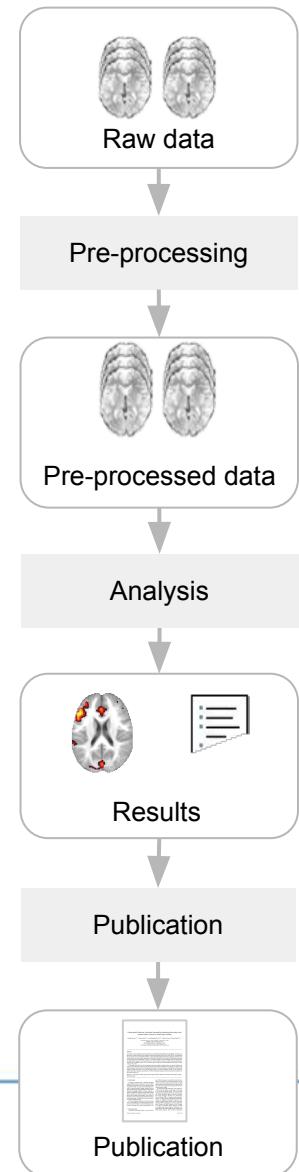


Data sharing



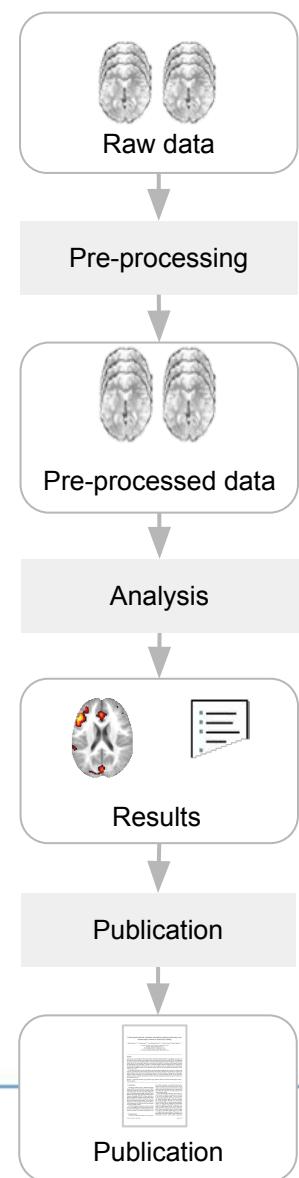
- Barriers to neuroimaging data sharing
 - Ethical considerations
 - Privacy issues
 - Psychological barriers
 - Time consuming process

Data sharing

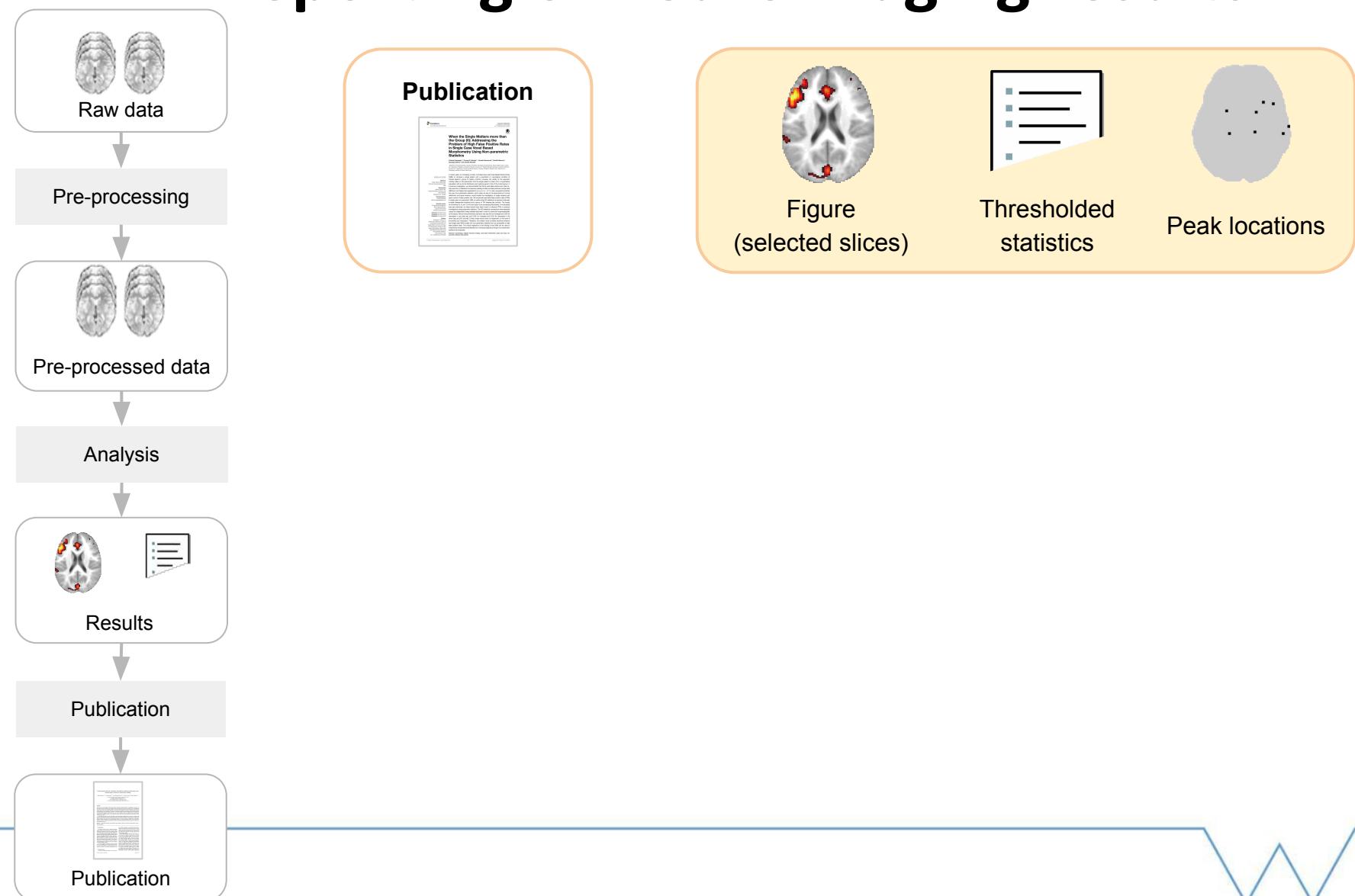


- Barriers to neuroimaging data sharing
 - Ethical considerations
 - Privacy issues
 - Psychological barriers
 - Time consuming process
- “Reporting” rather than “sharing”

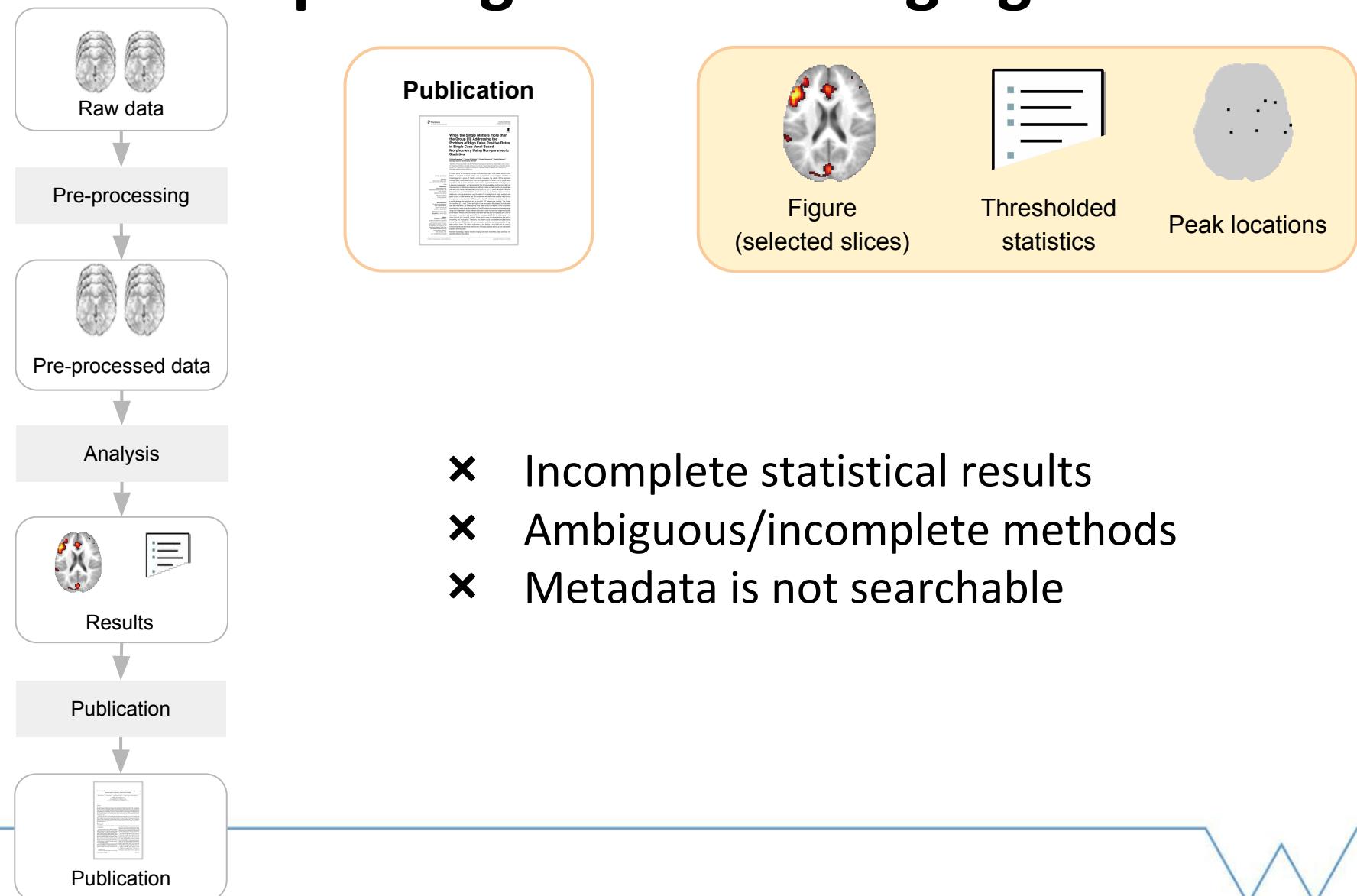
Reporting of neuroimaging results



Reporting of neuroimaging results



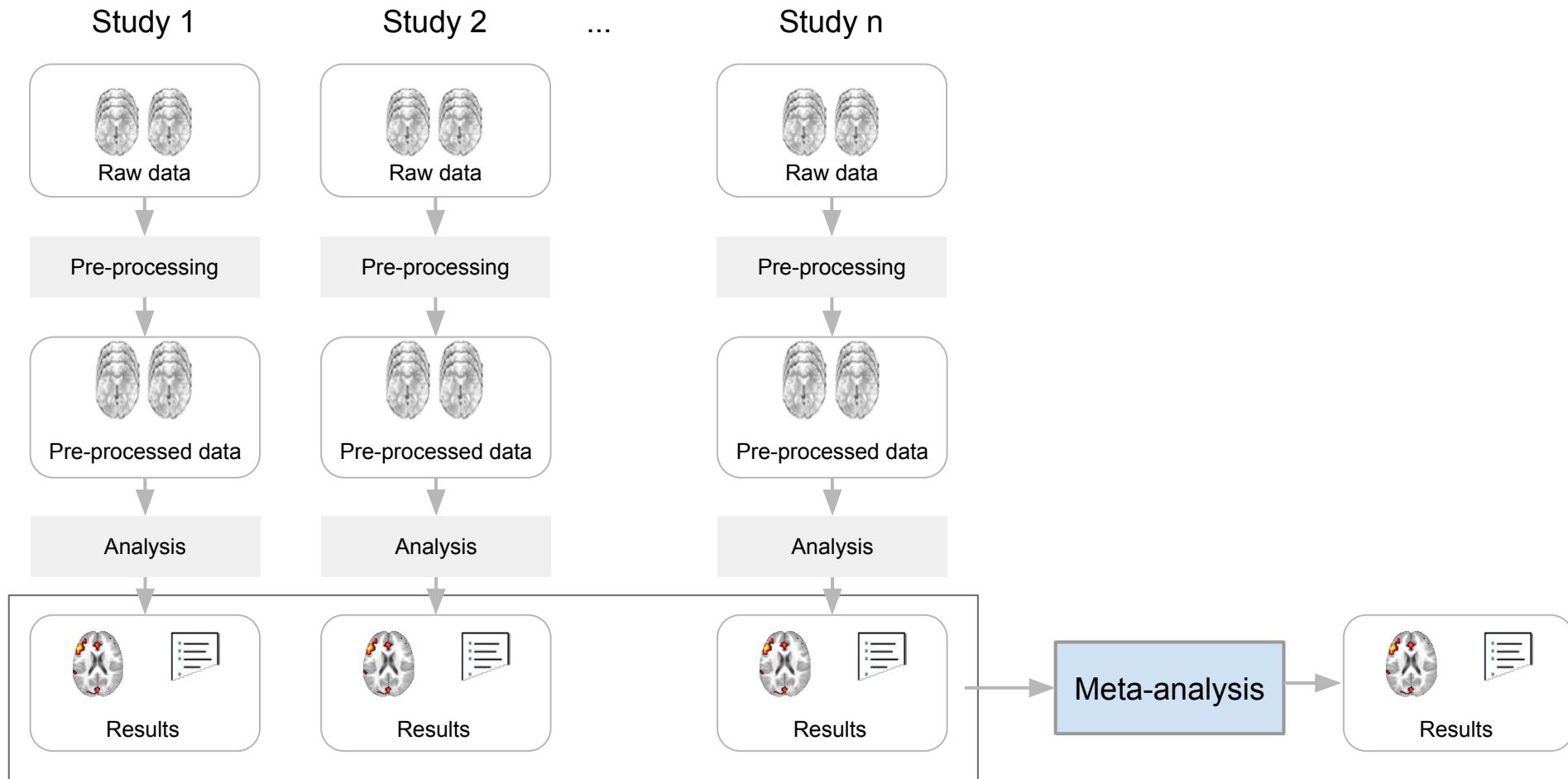
Reporting of neuroimaging results



Background

Neuroimaging meta-analyses

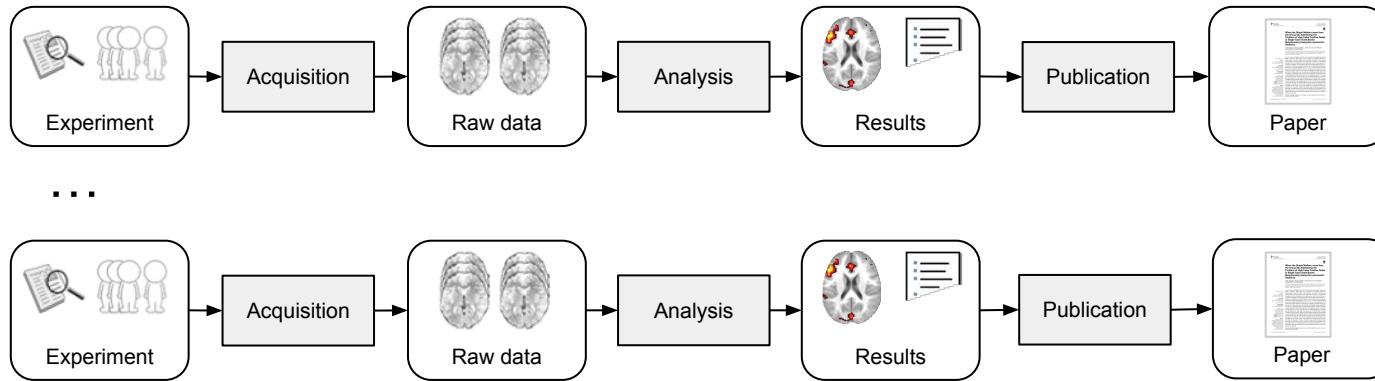
Meta-analysis



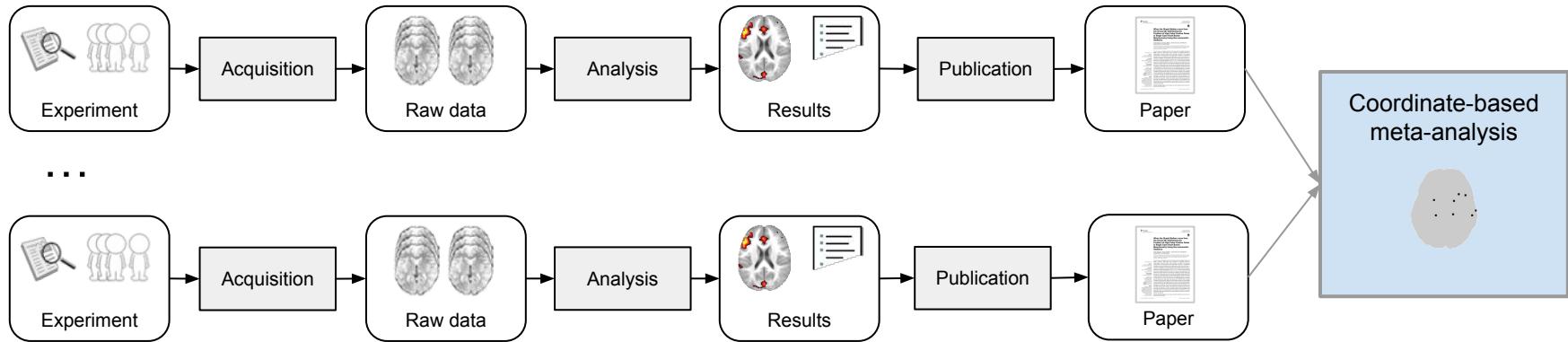
Neuroimaging meta-analysis

- Rich fMRI literature
 - > 30,000 articles (“fMRI” pubmed)
- Synthesize information across studies
- Increase statistical power

Coordinate- or Image-Based?



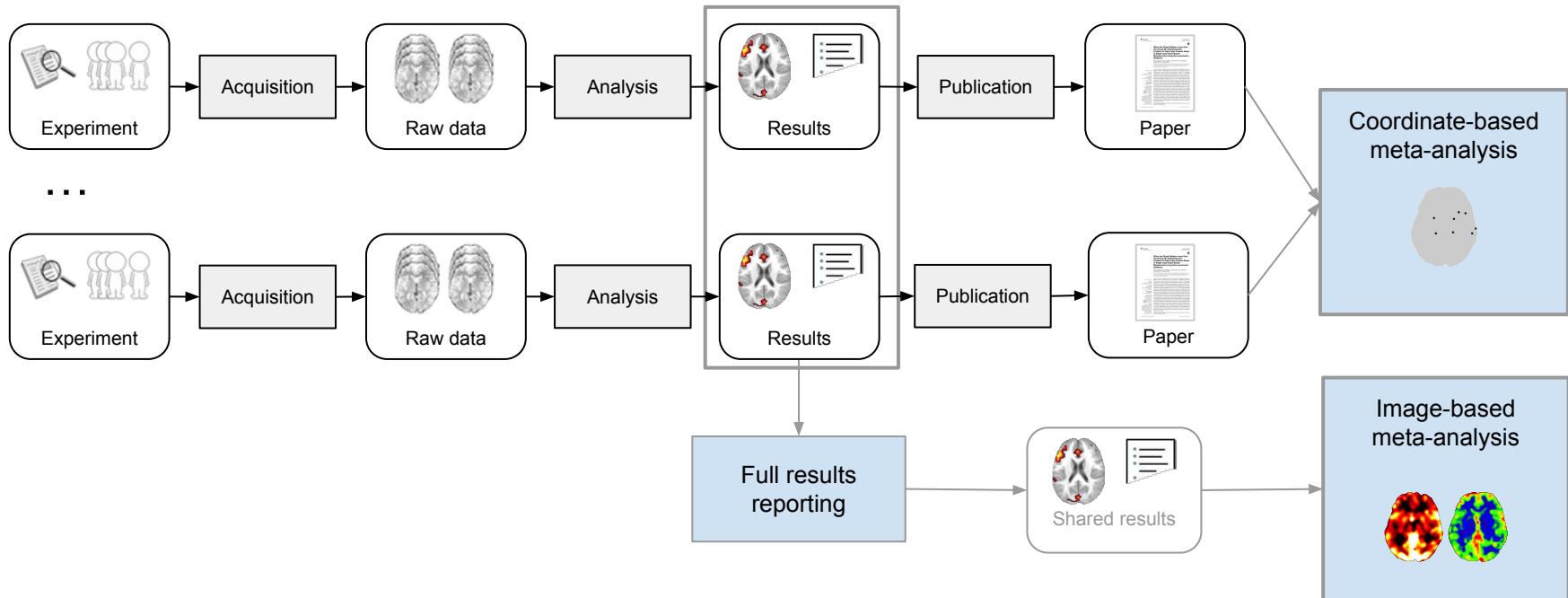
Coordinate- or Image-Based?



Coordinate-based meta-analysis



Coordinate- or Image-Based?



Coordinate-based meta-analysis



Image-based meta-analysis



The Neuroimaging Data Model (NIDM)

INCF Neuroimaging Task Force

- International collaboration
 - 13 labs, >12 tools
 - Weekly teleconferences, focused workshops, GitHub
 - Open



NIDM: a set of specifications to describe neuroimaging data

NIDM Experiment



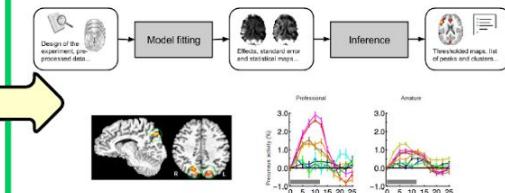
Data Acquisition

NIDM Workflow



Image Processing

NIDM Results



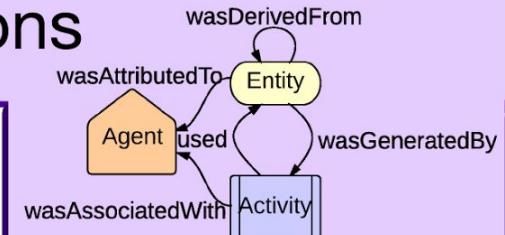
Statistical Model

NIDM Core Vocabulary

PROV Family of Specifications



Semantic Web Technologies



NIDM: a set of specifications to describe neuroimaging data

NIDM Experiment



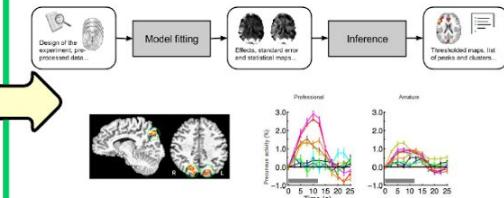
Data Acquisition

NIDM Workflow



Image Processing

NIDM Results



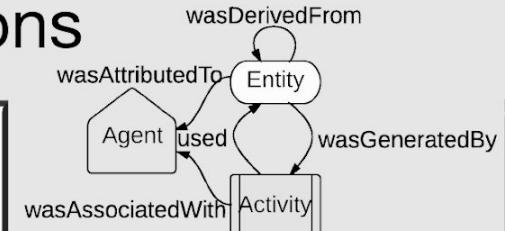
Statistical Model

NIDM Core Vocabulary

PROV Family of Specifications



Semantic Web Technologies

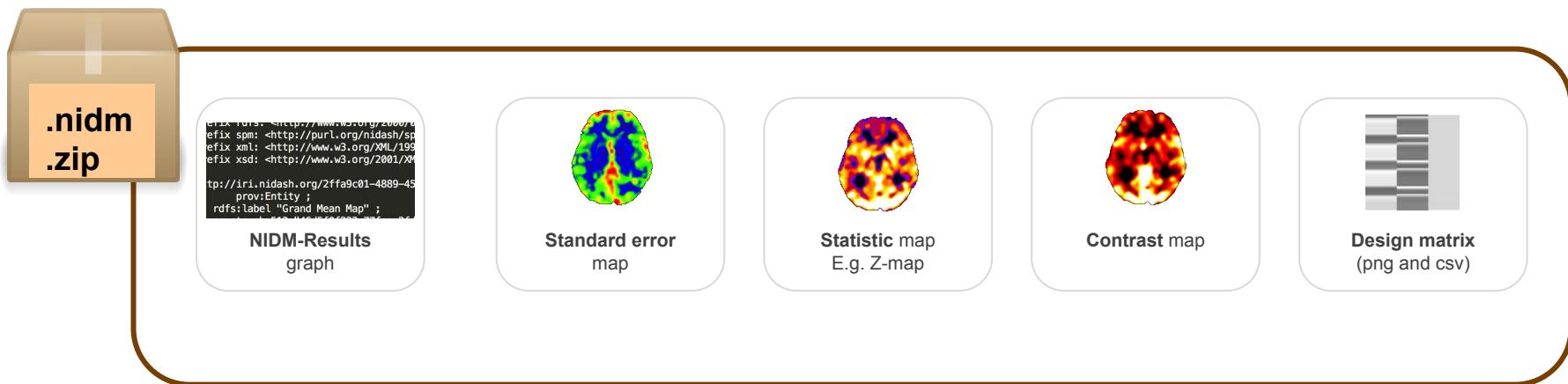


NIDM-Results

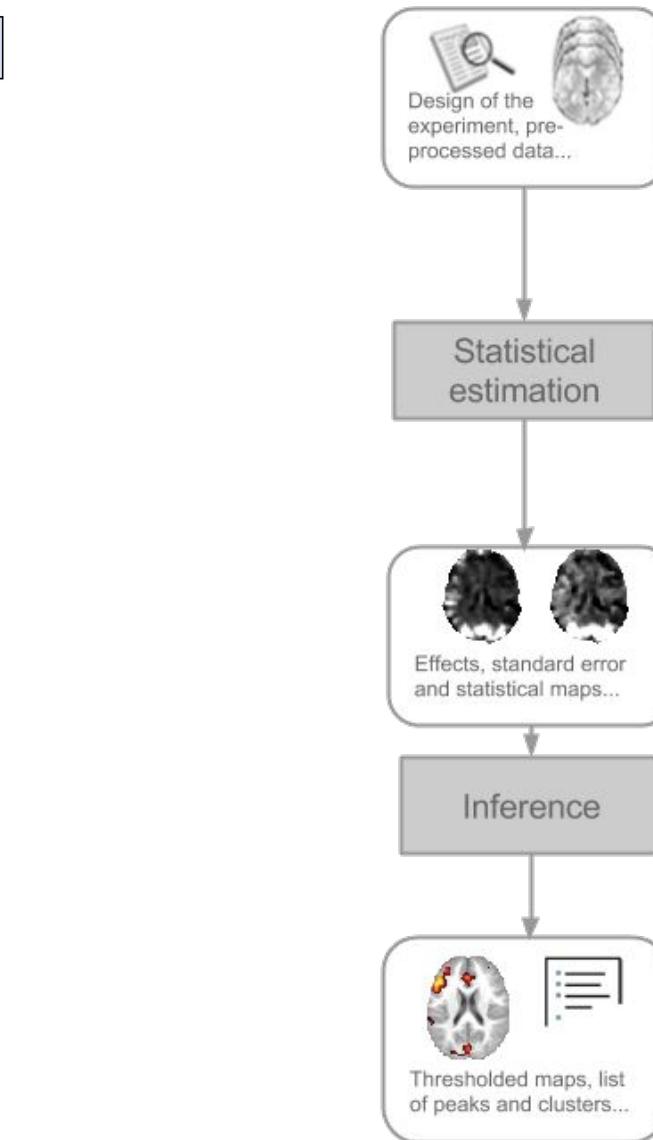
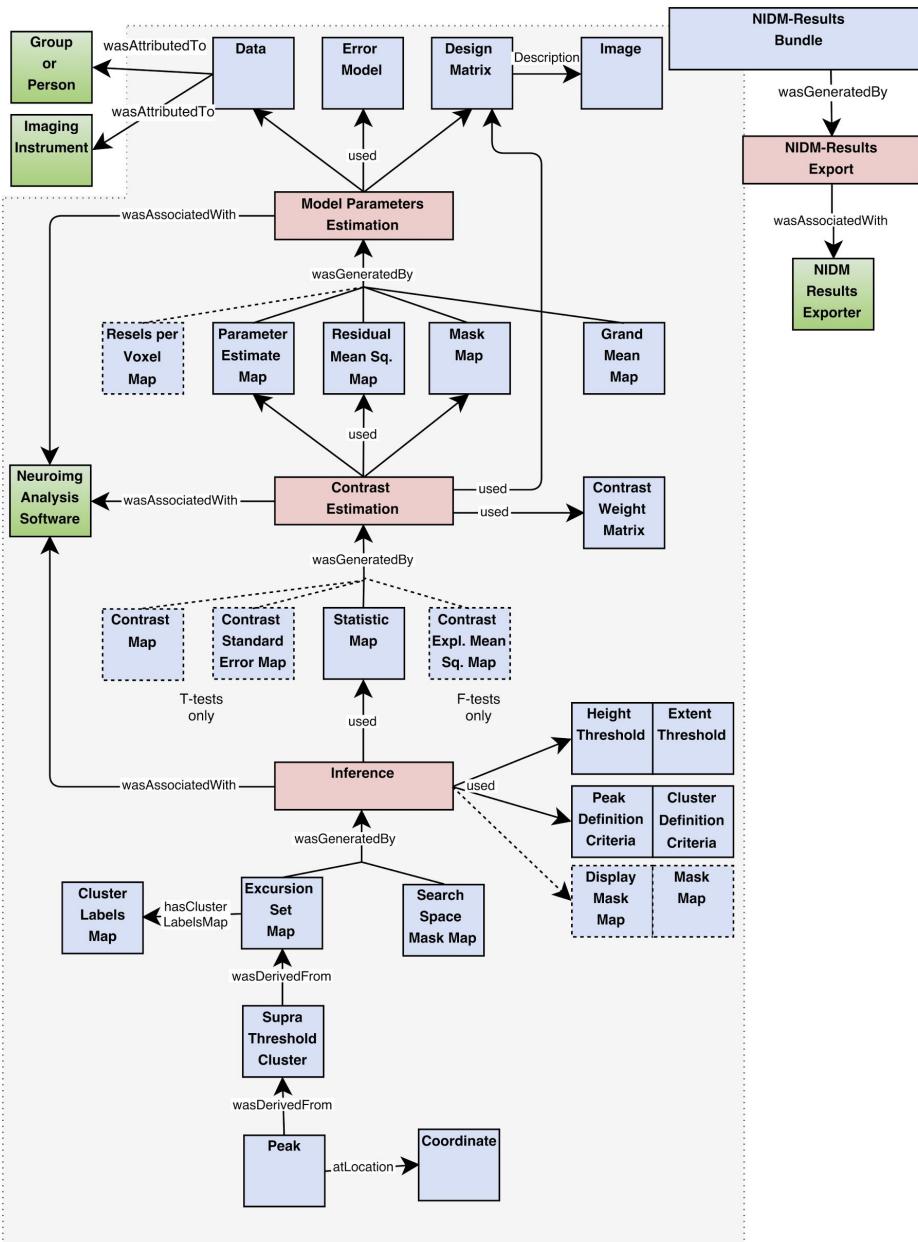
- Metadata selected according to
 - Meta-analysis use-case
 - Best practices
 - Neuroimaging software
- **Automatically** generated by the neuroimaging software packages.

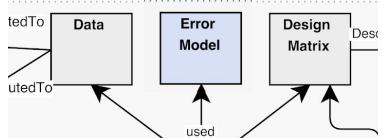
NIDM-Results

NIDM-Results pack: Compressed file containing a NIDM-Results serialization and some or all of the referenced image data files.



NIDM-Results





Specification

nidm:'Error Model': Model used to describe the random variation of the error term as part of parameter estimation, including specification of the error probability distribution, its variance and dependence both spatially and across observations.

nidm:'Error Model' is a prov:'Entity' used by nidm:'Model Parameter Estimation'.

A nidm:'Error Model' has attributes:

- rdfs:label: (OPTIONAL) Human readable description of the nidm:'Error Model'.
- **nidm:'dependence Map-Wise Dependence'**: (OPTIONAL) Property that associates an 'Error Parameter Map-Wise Dependence' to the dependence of an 'Error Model'. (range nidm:'Error Parameter Map-Wise Dependence' such as nidm:'Constant Parameter', nidm:'Independent Parameter', nidm:'Regularized Parameter').
- **nidm:'error Variance Homogeneous'**: (OPTIONAL) A boolean value reflecting how the variance of the error is modeled during parameter estimation; TRUE for constant variance over all observations in the model, FALSE for heterogeneous variance. (range xsd:boolean).
- **nidm:'has Error Dependence'**: (OPTIONAL) Property that associates a covariance structure representing the dependence structure of the error, used as part of model estimation with an 'Error Model'. (range obo:'covariance_structure' such as nidm:'Exchangeable Error', nidm:'Independent Error', obo:'Toeplitz covariance structure', obo:'compound symmetry covariance structure', obo:'unstructured covariance structure').
- **nidm:'has Error Distribution'**: (OPTIONAL) Property that associates a Probability distribution used to model the error with an ErrorModel. (range obo:'probability_distribution' such as obo:'continuous probability distribution', obo:'discrete probability distribution').
- **nidm:'variance Map-Wise Dependence'**: (OPTIONAL) Property that associates an 'Error Parameter Map-Wise Dependence' to the variance of an 'Error Model'. (range nidm:'Error Parameter Map-Wise Dependence' such as nidm:'Constant Parameter', nidm:'Independent Parameter', nidm:'Regularized Parameter').

Definition

Attributes

Examples

EXAMPLE 19: Error Model: Ordinary least squares

```

@prefix nidm_ErrorModel: <http://purl.org/nidash/nidm#NIDM_000023> .
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@prefix nidm_errorVarianceHomogeneous: <http://purl.org/nidash/nidm#NIDM_0000094> .
@prefix nidm_varianceMapWiseDependence: <http://purl.org/nidash/nidm#NIDM_0000126> .
@prefix nidm_hasErrorDependence: <http://purl.org/nidash/nidm#NIDM_0000100> .
@prefix nidm_dependenceMapWiseDependence: <http://purl.org/nidash/nidm#NIDM_0000089> .
@prefix nidm_IndependentParameter: <http://purl.org/nidash/nidm#NIDM_0000073> .
@prefix nidm_IndependentError: <http://purl.org/nidash/nidm#NIDM_0000048> .
@prefix obo_normaldistribution: <http://purl.obolibrary.org/obo/STATO_0000227> .


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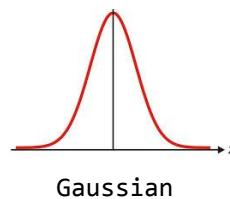
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niiri:error_model_id a prov:Entity , nidm_ErrorModel: ;
  nidm_hasErrorDistribution: obo_normaldistribution: ;
  nidm_errorVarianceHomogeneous: "true"^^xsd:boolean ;
  nidm_varianceMapWiseDependence: nidm_IndependentParameter: ;
  nidm_hasErrorDependence: nidm_IndependentError: ;
  nidm_dependenceMapWiseDependence: nidm_IndependentParameter: .

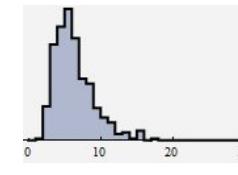
```

Harmonisation across software

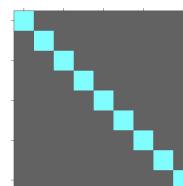
- Model of the error
 - Prob. distribution:
 - Variance:



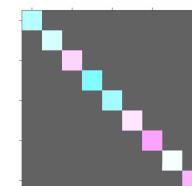
Gaussian



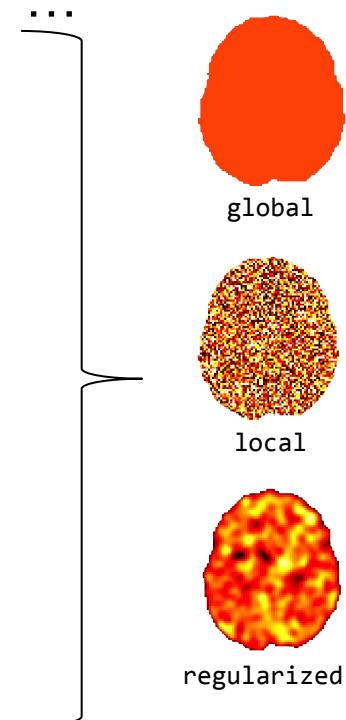
Non-Parametric



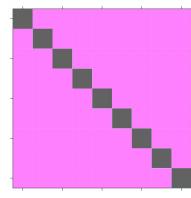
homogeneous



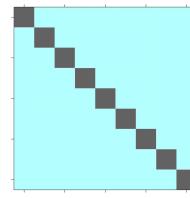
heterogeneous



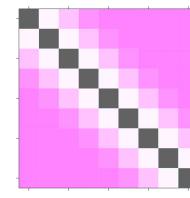
- Dependence:



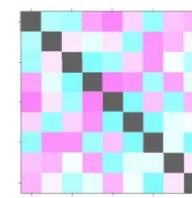
Independent noise



Compound Symmetry



Serially correlated



Arbitrarily correlated

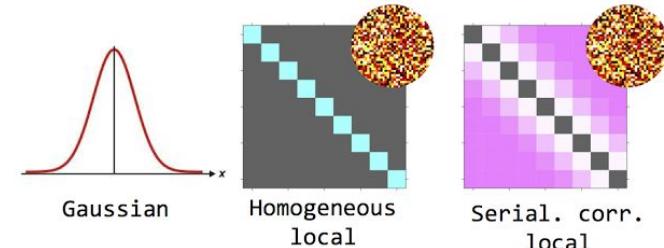
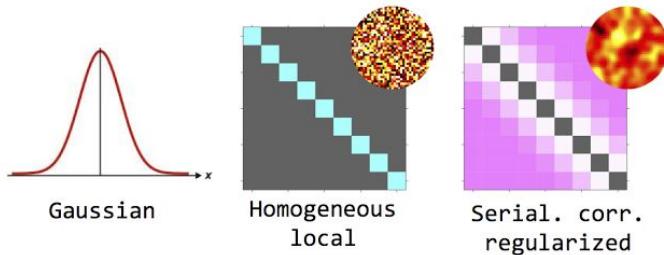
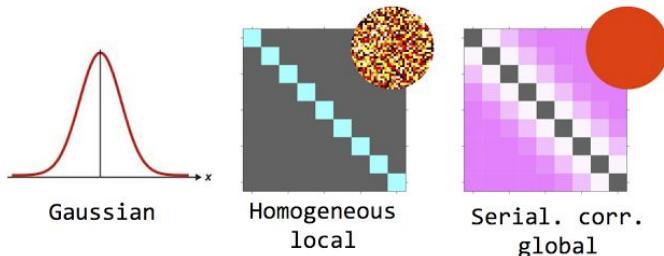
Error models: SPM, FSL and AFNI

SPM

FSL

AFNI

Subject level

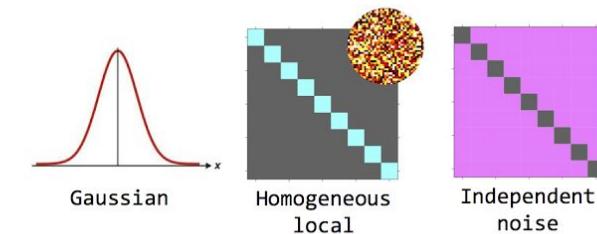
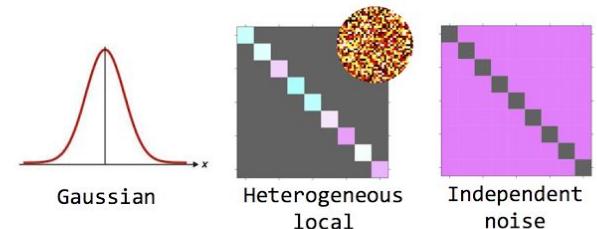
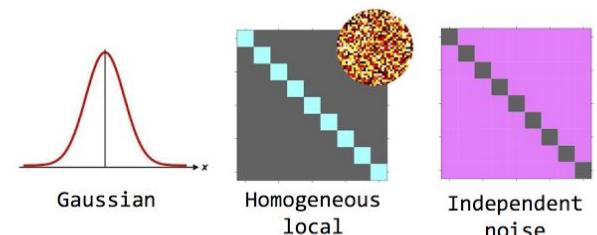


SPM
one sample
t-test

FSL
FLAME 1

3dttest++

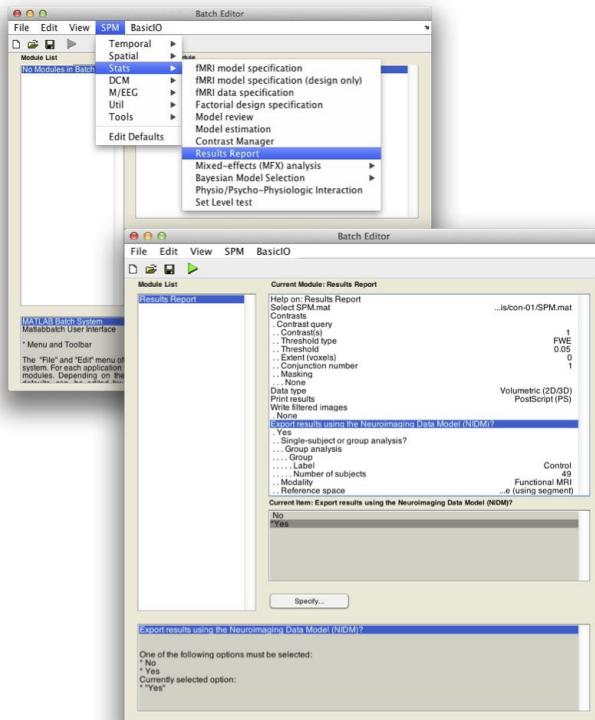
Group level



An image-based meta-analysis with NIDM-Results

SPM export to NIDM

SPM



Name	Size	Kind
beta_0001.nii	2.4 MB	NIFTI
con_0001.nii	2.4 MB	NIFTI
mask.nii	593 KB	NIFTI
nidm_001.nidm.zip	4.1 MB	ZIP archive
ResMS.nii	4.7 MB	NIFTI
RPV.nii	4.7 MB	NIFTI
SPM.mat	484 KB	MATLAB Data
spmT_0001.nii	2.4 MB	NIFTI

- Available as part of SPM12

FSL export to NIDM



```
$ nidmfsl ds107.gfeat -g Control 49
```



Name	Size	Kind
design.con	126 bytes	Document
design.fsf	20 KB	Document
design.grp	131 bytes	Document
design.icon	28 bytes	Document
cope1.feat	--	Folder
cope2.feat	--	Folder
inputreg	--	Folder
logs	--	Folder
bg_image.nii.gz	3.4 MB	gzip compressed archive
mask.nii.gz	15 KB	gzip compressed archive
mean_func.nii.gz	2.8 MB	gzip compressed archive
report_firstlevel.html	10 KB	HTML document
report_log.html	55 KB	HTML document
report_reg.html	17 KB	HTML document
report_stats.html	495 bytes	HTML document
report.html	922 bytes	HTML document
design.mat	732 bytes	MATLAB Data
design_cov.ppm	6 KB	OpenOffice.app Document
design.ppm	219 KB	OpenOffice.app Document
design_cov.png	106 bytes	Portable Network Graphics image
design.png	1 KB	Portable Network Graphics image
fsl_ds107_group.nidm.zip	13.6 MB	ZIP archive

- Install via pip
- To be included in the next FSL release

Upload to NeuroVault

The screenshot shows the NeuroVault homepage. At the top, there is a blue header bar with the text "NeuroVault", "Collections", "FAQ", and "Give feedback" on the left, and a search icon and "Log in" button on the right. Below the header is a large central image featuring a stylized brain graphic above the word "NEUROVAULT" in bold, black, sans-serif capital letters. Below the title, a subtitle reads: "A public repository of unthresholded statistical maps, parcellations, and atlases of the human brain". To the left, under the heading "What is it?", is a description: "A place where researchers can publicly store and share unthresholded statistical maps, parcellations, and atlases produced by MRI and PET studies." To the right, under the heading "Why use it?", is a bulleted list: "Interactive visualization", "A permanent URL", "Publicly shareable", and "Improves meta-analyses". At the bottom of the main content area is a blue button with the text "Get started and upload an image!". On the far right, there is some decorative blue line art.

What is it?

A place where researchers can publicly store and share unthresholded statistical maps, parcellations, and atlases produced by MRI and PET studies.

Why use it?

- Interactive visualization
- A permanent URL
- Publicly shareable
- Improves meta-analyses

Get started and upload an image!

Supported by

Stanford University

Upload to NeuroVault

NeuroVault Collections ▾ FAQ Give feedback Log in

A Correspondence between Individual Differences in the Brain's Intrinsic Functional Architecture and the Content and Form of Self-Generated Thoughts

Contributed by ChrisFilipGorgolewski

Krzysztof J. Gorgolewski, Dan Lurie, Sebastian Urchs, Judy A. Kipping, R. Cameron Craddock, Michael P. Milham, Daniel S. Margulies, Jonathan Smallwood

[Link to the paper](#)

[3D View](#)

File View Options

x y z 0
0 -18 18 0

Images Details

Show 7 entries Search:

View	ID	Name	Type
	25	fALFF: Past	Z map
	26	fALFF: Future	Z map
	27	fALFF: Past > Future	Z map
	28	fALFF: Positive	Z map
	29	fALFF: Negative	T map
	30	fALFF: Positive > Negative	Z map
	31	fALFF: Social Cognition	Z map

Showing 1 to 7 of 30 entries [First](#) [Previous](#) [Next](#) [Last](#)

Upload to NeuroVault

NeuroVault

Collections ▾

FAQ

Give feedback



cmaumet ▾

My NIDM-Results collection

Contributed by cmaumet

Add image

Edit ▾

Upload ▾

Delete collection

Private Collection: To share the link to this collection, please use the private url: </collections/DFSNYVPQ/>

This collection is empty. You can:

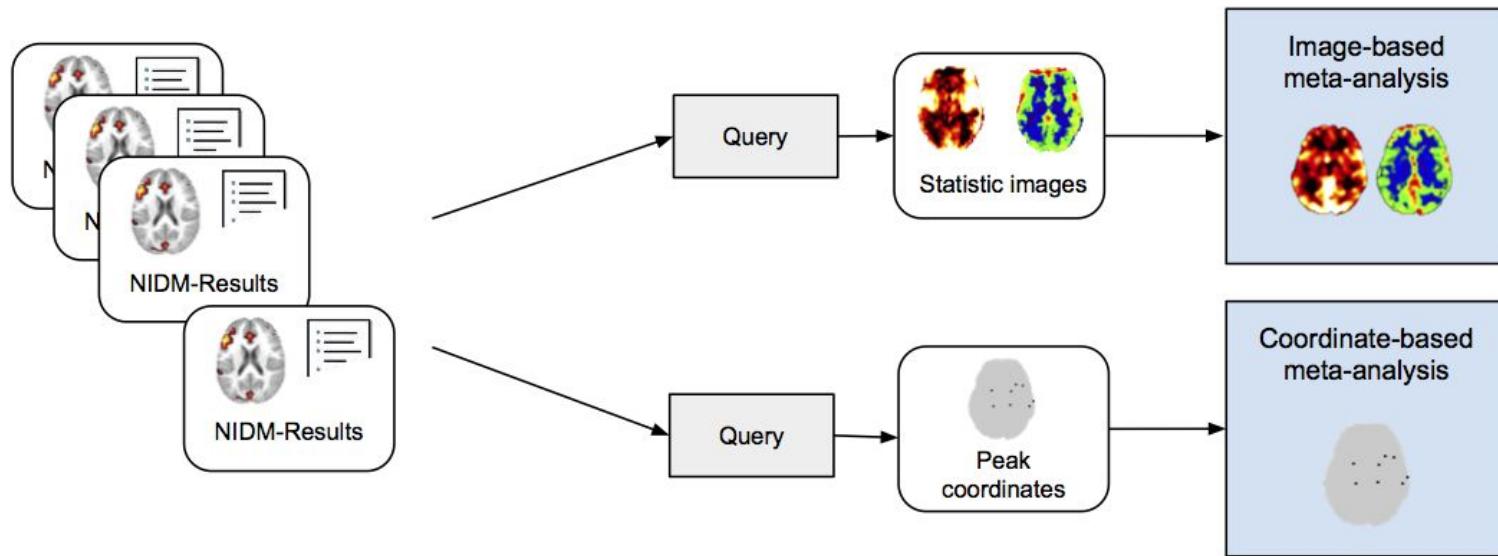
[Add images one by one](#)

[Upload an archive with images \(.zip or .tar.gz\)](#)

[Upload a NIDM-Results file \(.nidm.zip\)](#)

[Upload a folder with images](#)

Example of meta-analysis



Coordinate-based meta-analysis



Image-based meta-analysis



Conclusion

Conclusion

NIDM-Results: a model for full reporting of mass-univariate results

Future work

- Model extensions (e.g. permutation)
- Ecosystem of tools
- NIDM-Experiment (BIDS),
NIDM-Workflows

Acknowledgements

Thank you! To all the INCF NIDASH task force members.

Warwick neurodata sharing Tom Nichols, Alex Bowring, Ruth Pauli, Peter Williams, Tom Maullin-Sapey.

NIDM working group Tibor Auer, Samir Das, Fariba Fana, Guillaume Flandin, Satra Ghosh, Tristan Glatard, Chris Gorgolewski, Karl Helmer, David Keator, Nolan Nichols, Jean-Baptiste Poline, Vanessa Sochat, Jason Steffener, Jessica Turner.

SPM Guillaume Flandin.

FSL Mark Jenkinson, Matthew Webster, Paul McCarthy, Eugene Duff, Steve Smith.

AFNI Gang Chen, Richard Reynolds, Ziad Saad, Robert Cox.

Meta-analysis dataset Tracey group at FMRIB.

This work is supported by the



Q & A

Maumet, C. et al. Sharing brain mapping statistical results with the neuroimaging data model. *Sci. Data* 3:160102
doi: [10.1038/sdata.2016.102](https://doi.org/10.1038/sdata.2016.102) (2016).



<https://github.com/incf-nidash>

<http://nidm.nidash.org>