

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

Camille Maumet

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Camille Maumet. NIDM-Results: a model to share brain mapping statistical results. CBU Open Science Workshop 2016, Nov 2016, Cambridge, United Kingdom. . inserm-01887752

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MRC Cognition and Brain Sciences Unit

WARWICK
THE UNIVERSITY OF WARWICK

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

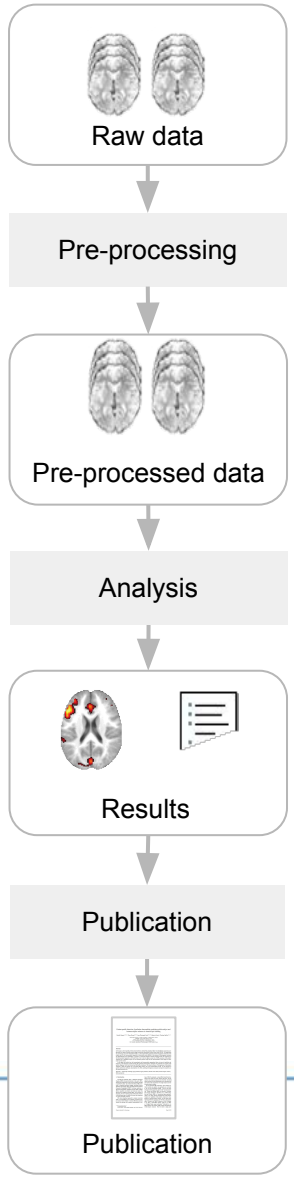
- Background
  - Reporting of neuroimaging results
  - Neuroimaging meta-analyses
- The NeuroImaging Data Model
- Example of image-based meta-analysis



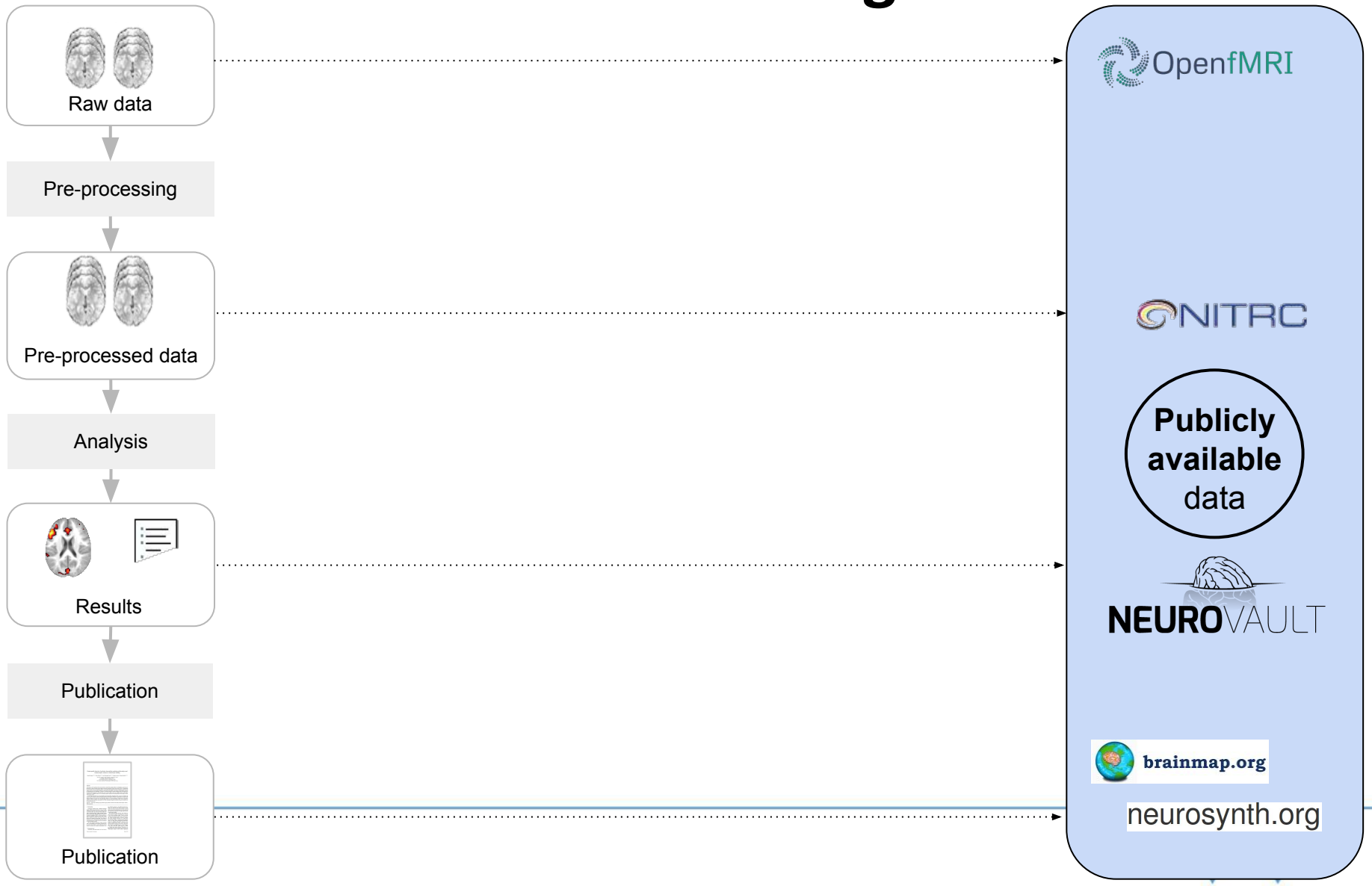
Background

Reporting of neuroimaging results

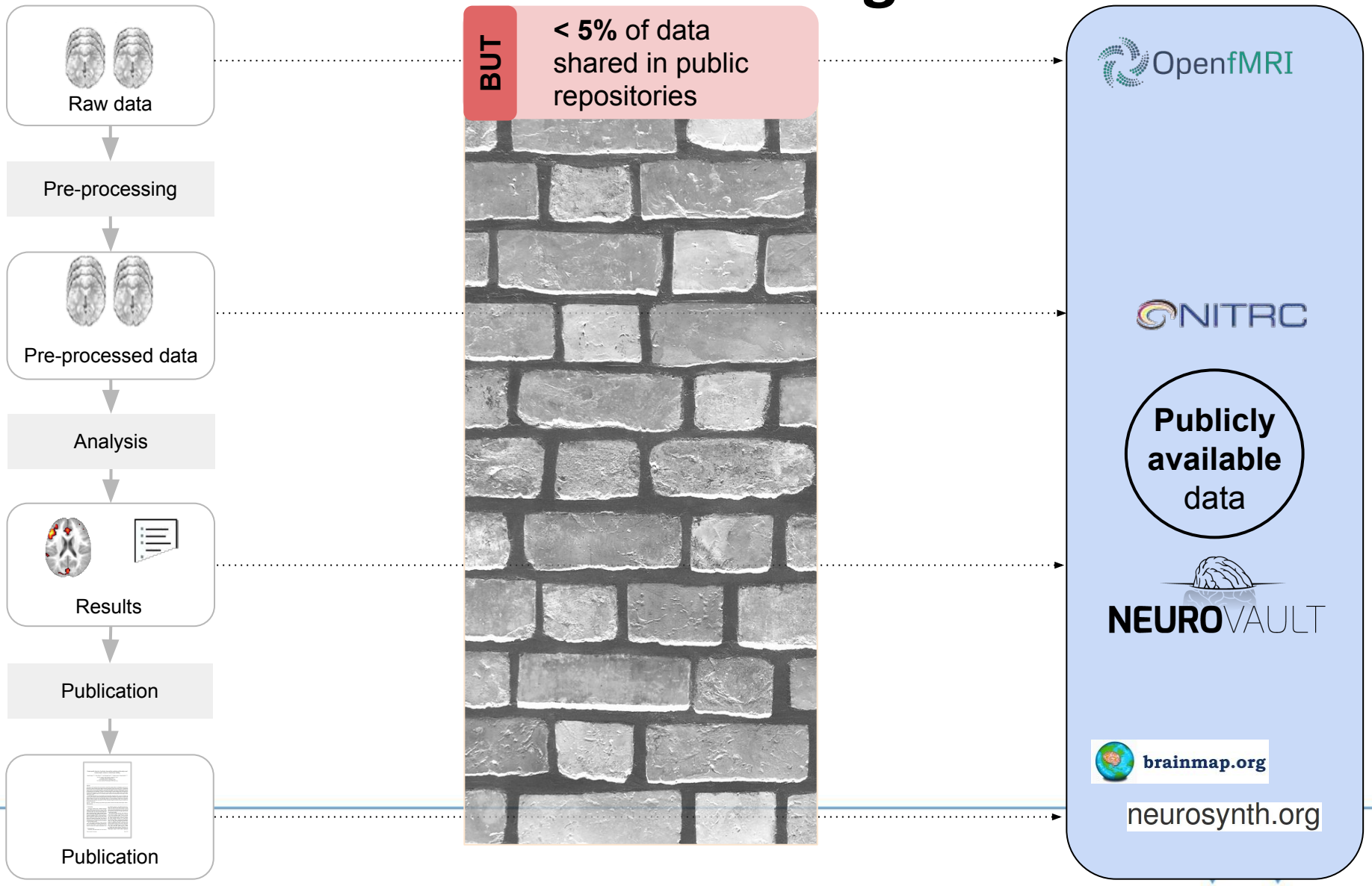
Data sharing



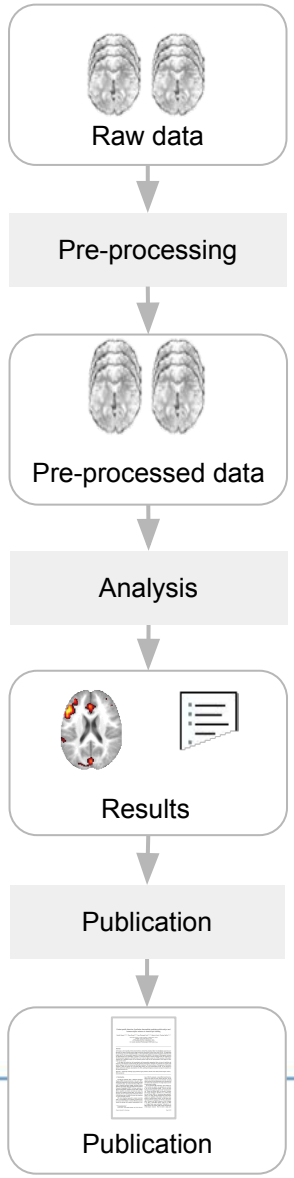
Data sharing



Data sharing

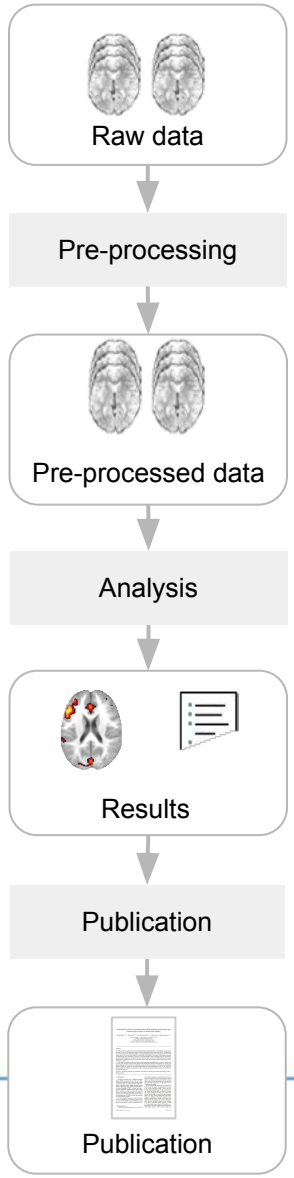


Data sharing



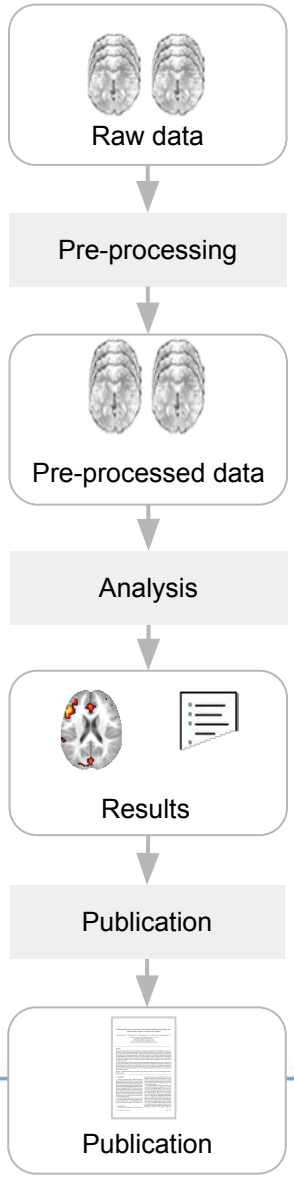
- Barriers to neuroimaging data sharing
  - **Ethical** considerations
  - **Privacy** issues
  - **Psychological** barriers
  - **Time consuming** process

Data sharing

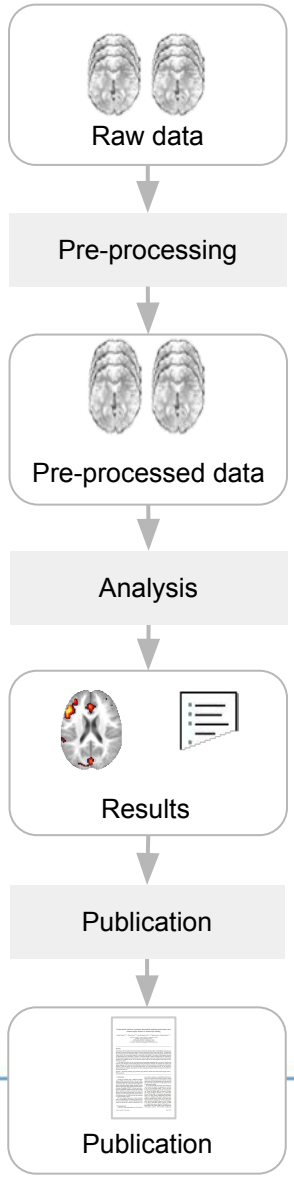


- Barriers to neuroimaging data sharing
  - **Ethical** considerations
  - **Privacy** issues
  - **Psychological** barriers
  - **Time consuming** process
- **“Reporting”** rather than **“sharing”**

Reporting of neuroimaging results



Reporting of neuroimaging results



Publication



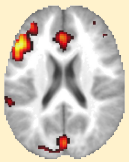


Figure
(selected slices)

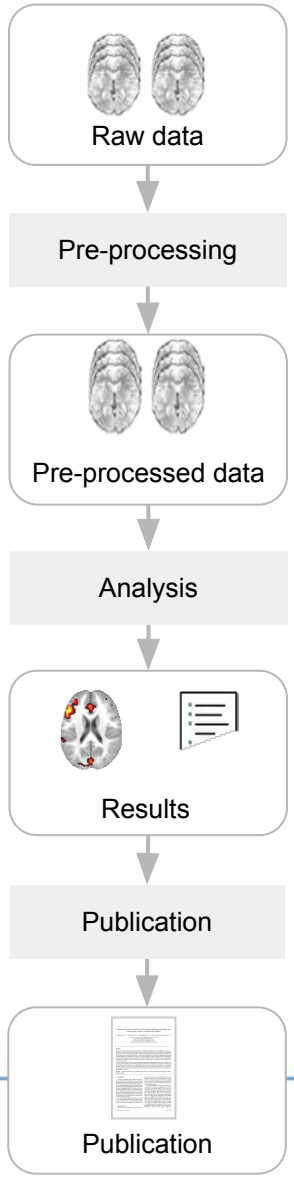


Thresholded
statistics



Peak locations

Reporting of neuroimaging results



Publication



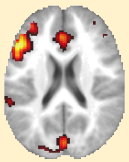


Figure
(selected slices)



Thresholded
statistics



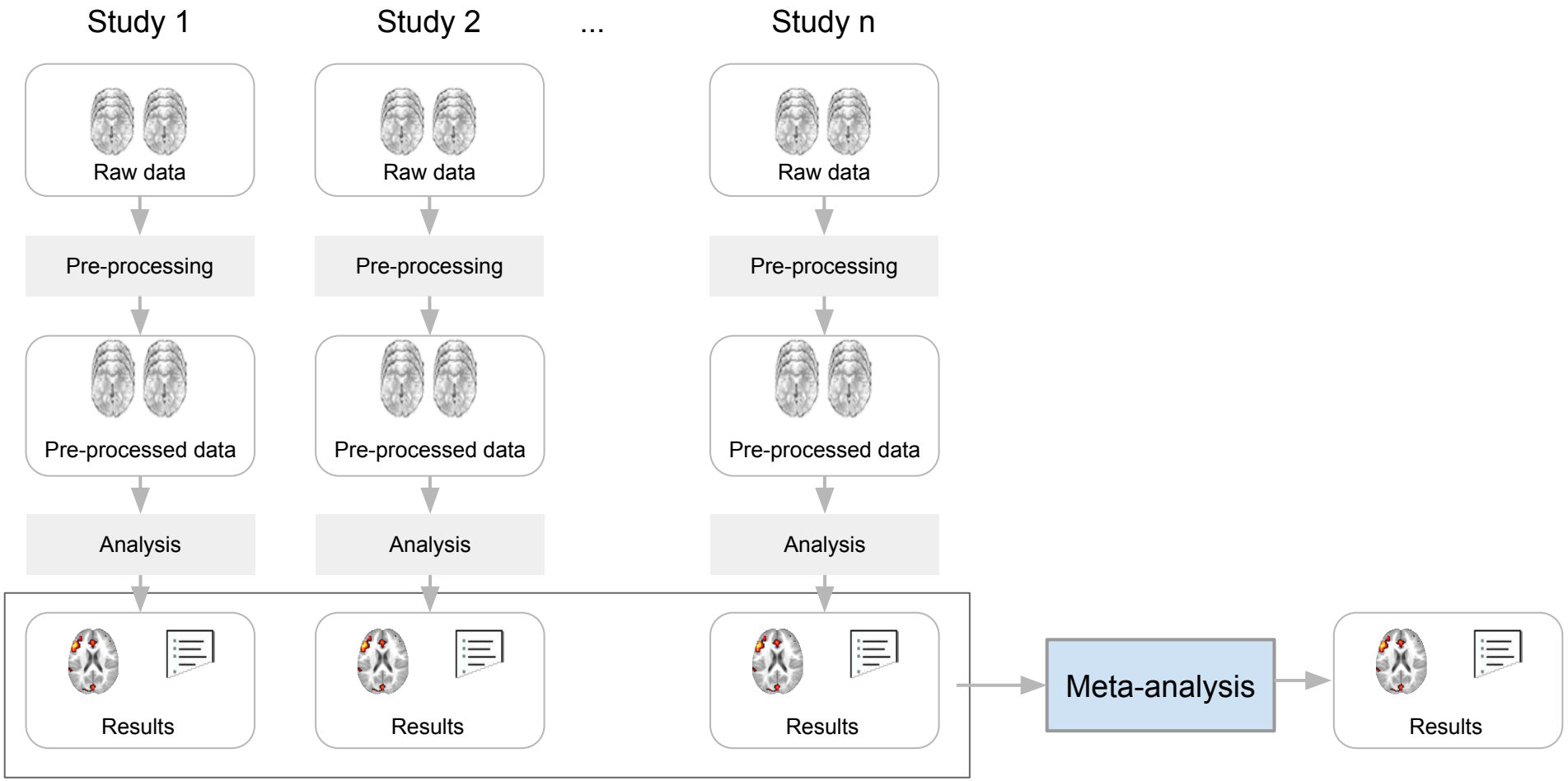
Peak locations

- ✕ Incomplete statistical results
- ✕ Ambiguous/incomplete methods
- ✕ Metadata is not searchable

Background

Neuroimaging meta-analyses

Meta-analysis



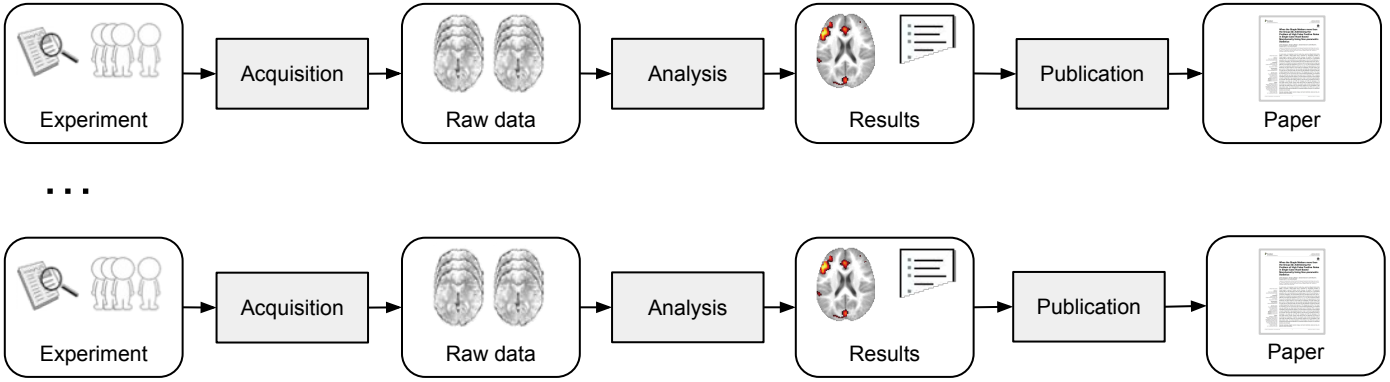
Neuroimaging meta-analysis

- Rich fMRI literature

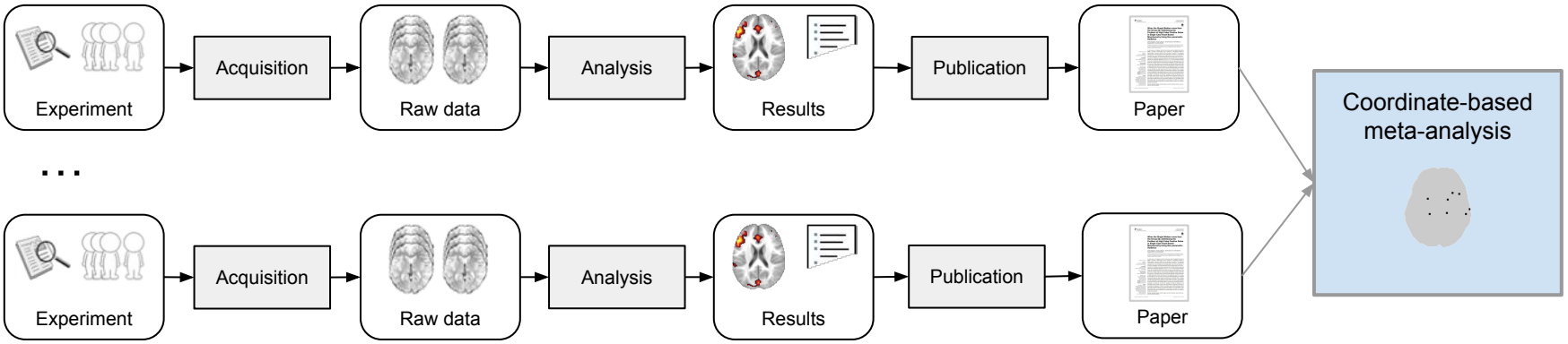
  > 30,000 articles (“fMRI” pubmed)

- Synthesize information across studies
- Increase statistical power

Coordinate- or Image-Based?



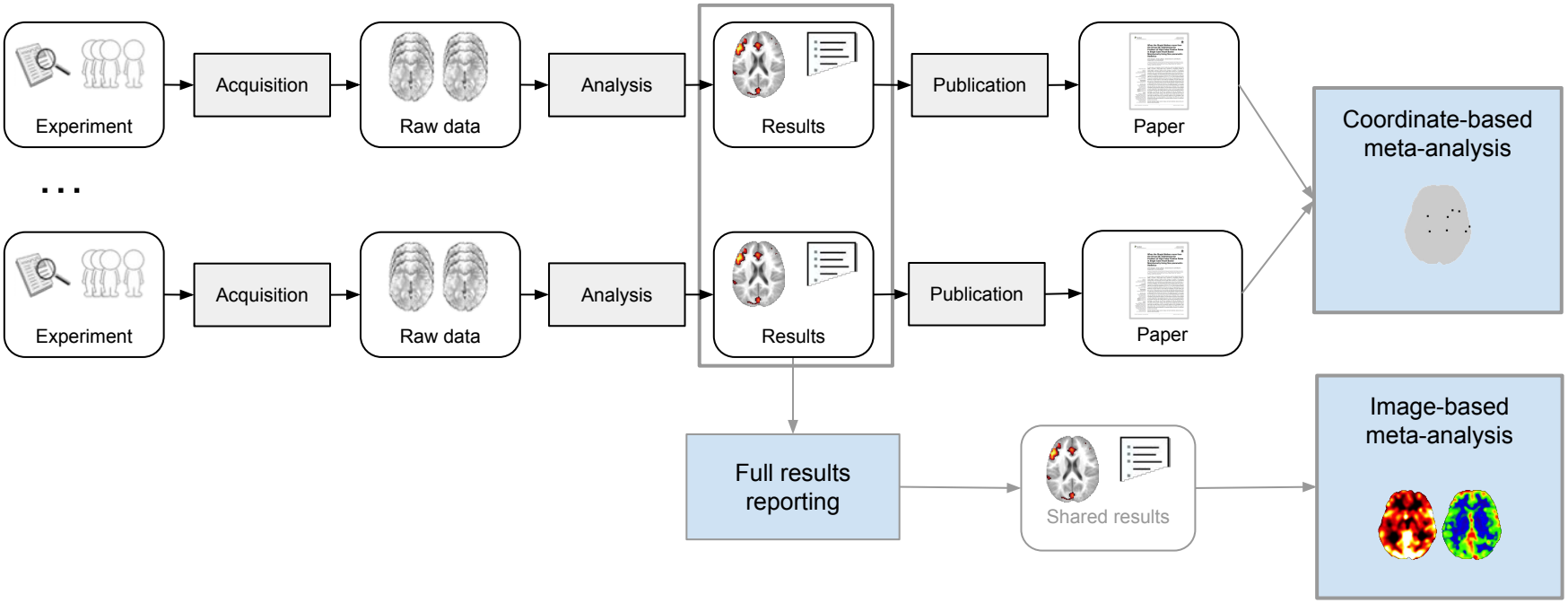
Coordinate- or Image-Based?

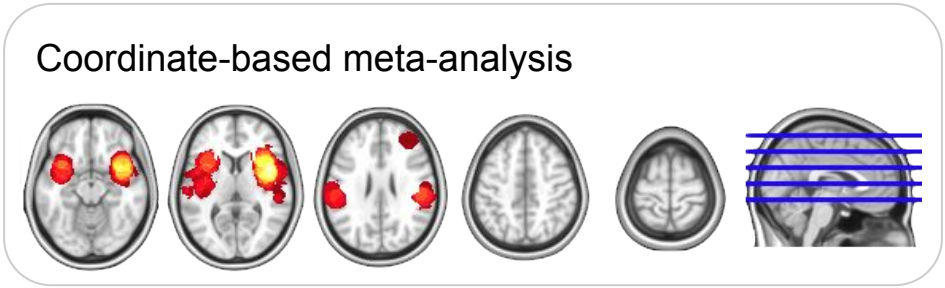


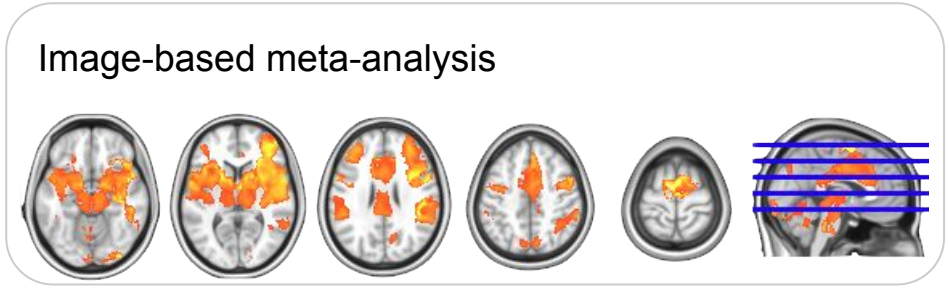
Coordinate-based meta-analysis



Coordinate- or Image-Based?





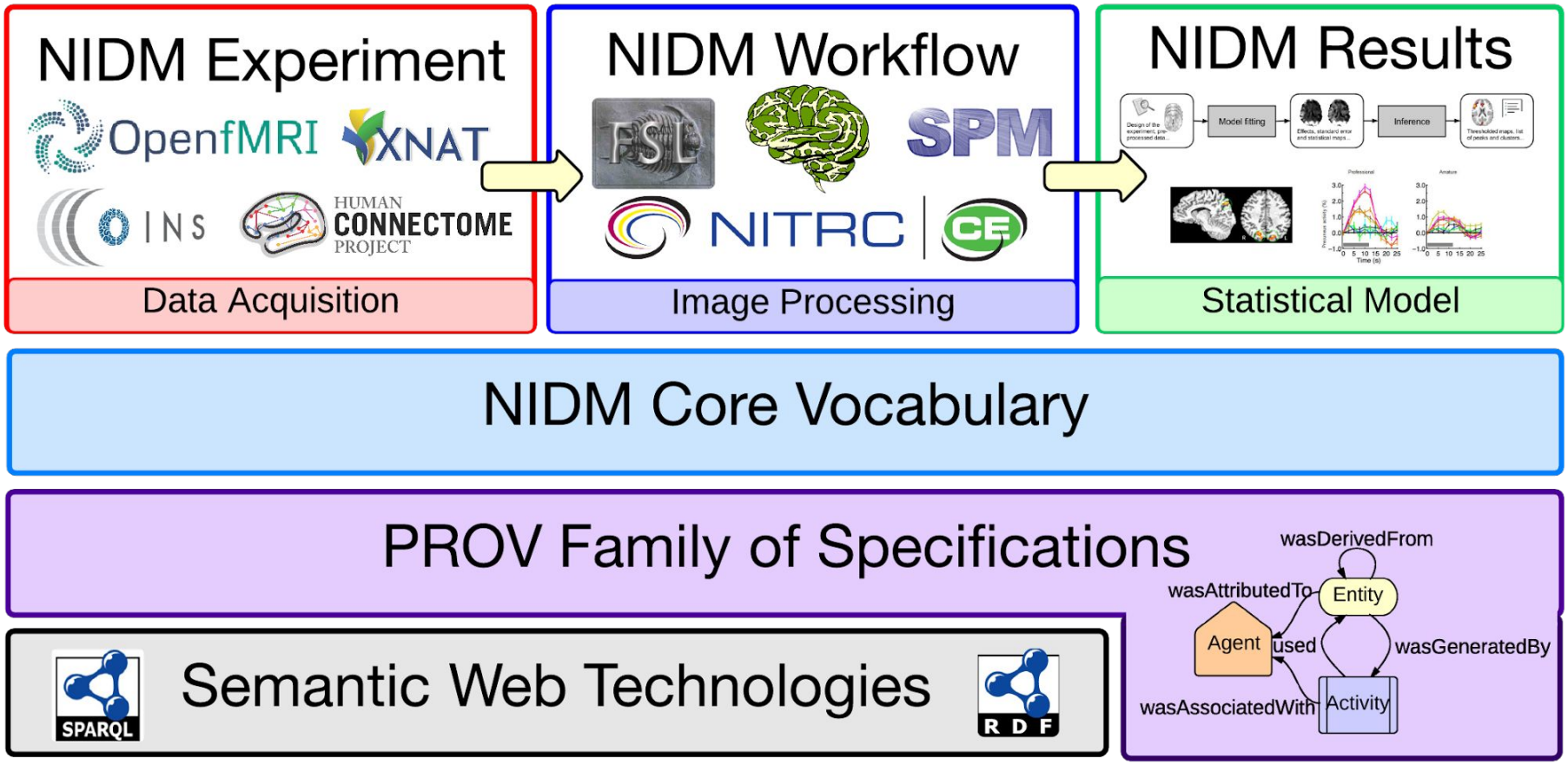


The Neuroimaging Data Model (NIDM)

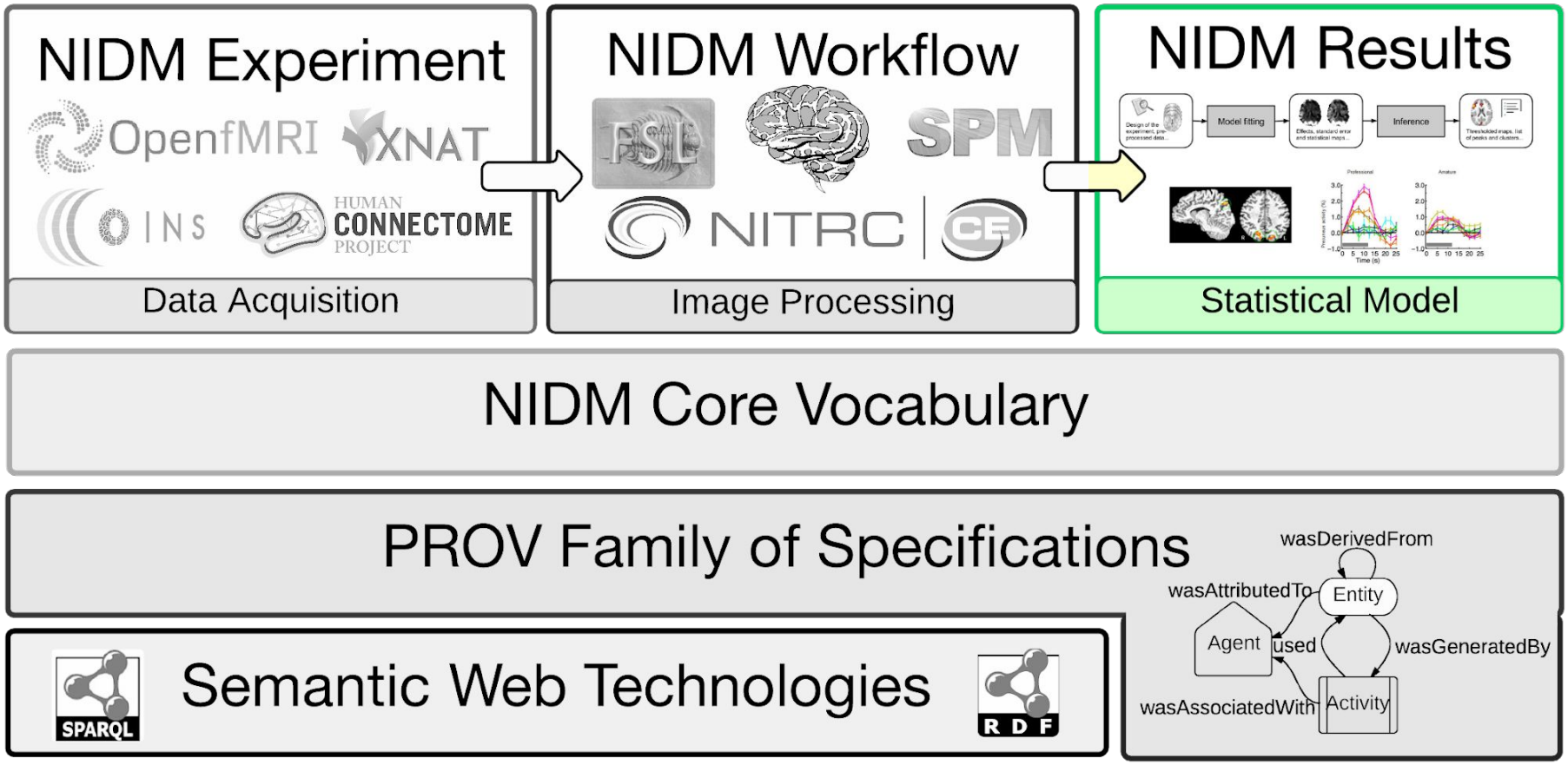
INCF Neuroimaging Task Force

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

NIDM: a set of specifications to describe neuroimaging data



NIDM: a set of specifications to describe neuroimaging data



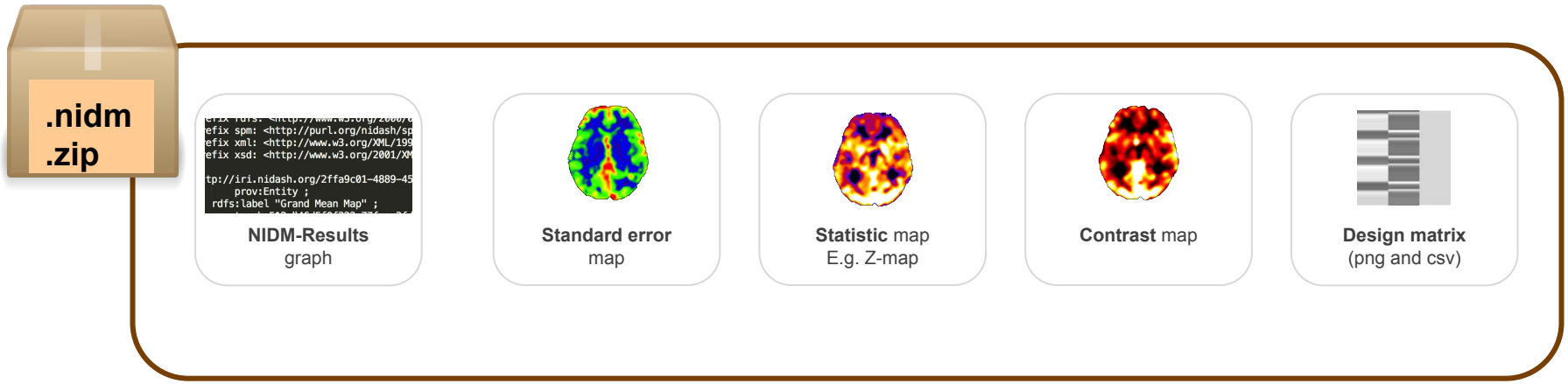
NIDM-Results

- Metadata selected according to
  - Meta-analysis use-case
  - Best practices
  - Neuroimaging software

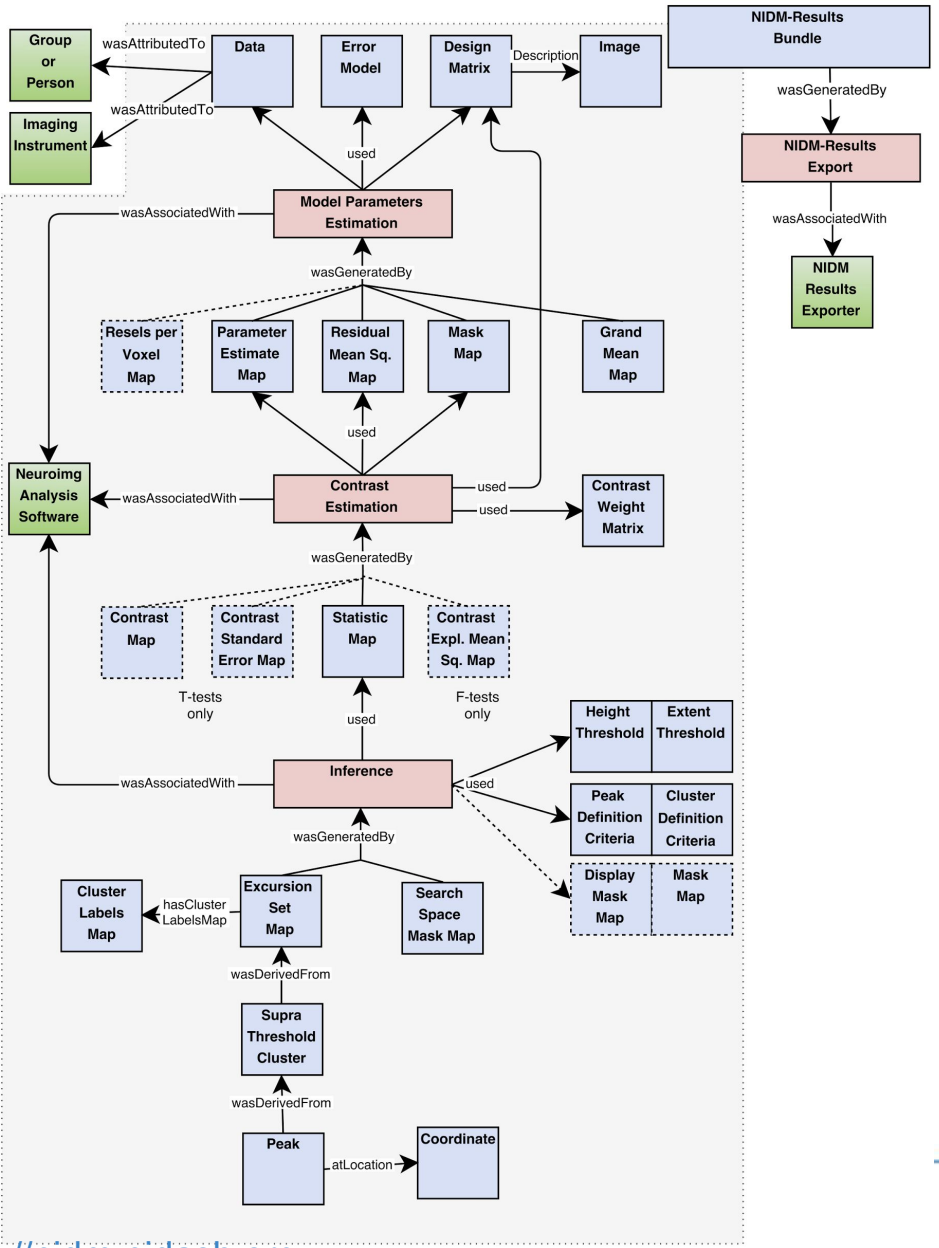
- **Automatically** generated by the neuroimaging software packages.

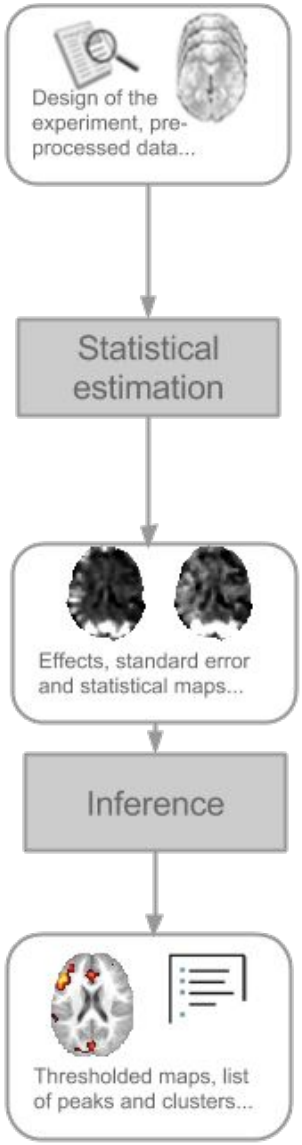
NIDM-Results

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

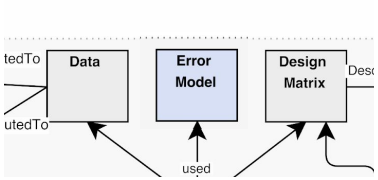


NIDM-Results





http://nidm.nidash.org



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').

EXAMPLE 19: Error Model: Ordinary least squares

```
@prefix nidm_ErrorModel: <http://purl.org/nidash/nidm#NIDM_0000023> .
@prefix nidm_hasErrorDistribution: <http://purl.org/nidash/nidm#NIDM_0000101> .
@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> .
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@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> .


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: .
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Definition

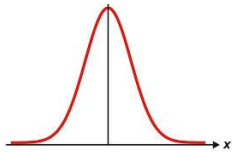
Attributes

Examples

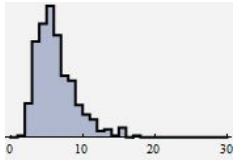
http://nidm.nidash.org/specs/nidm-results.html

Harmonisation across software

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

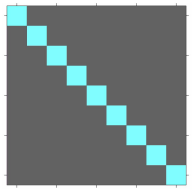


Gaussian

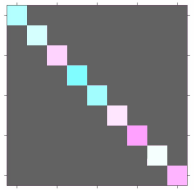


Non-Parametric

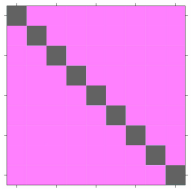
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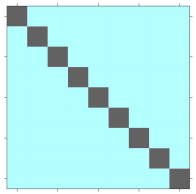
homogeneous



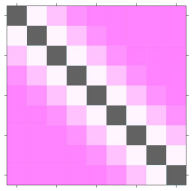
heterogeneous



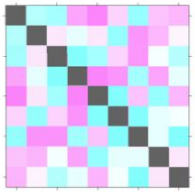
Independent noise



Compound Symmetry



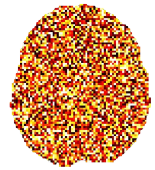
Serially correlated



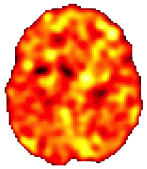
Arbitrarily correlated



global



local

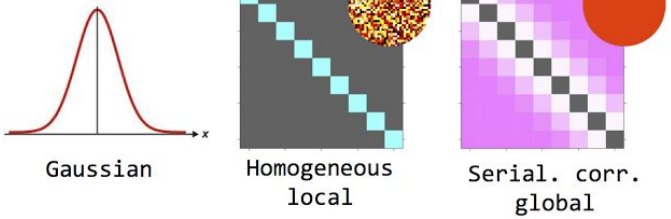


regularized

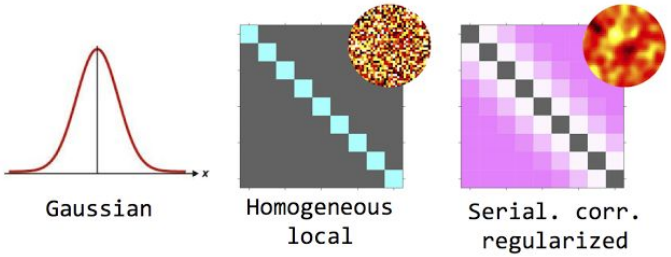
Error models: SPM, FSL and AFNI

Subject level

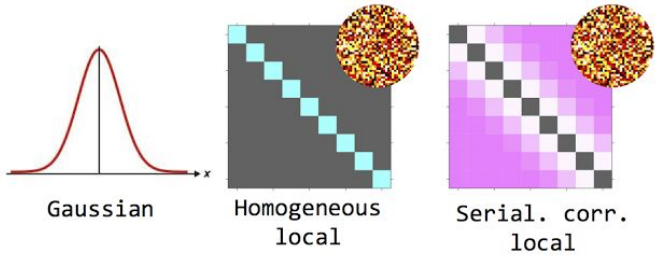
SPM



FSL

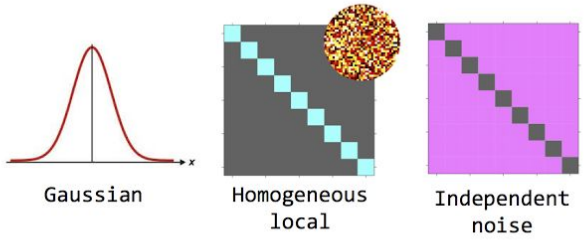


AFNI

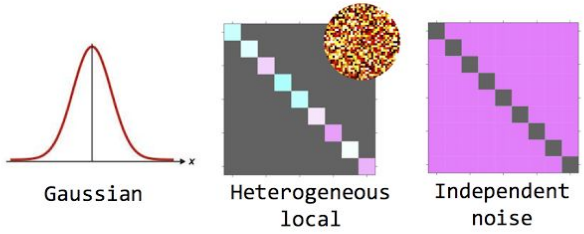


Group level

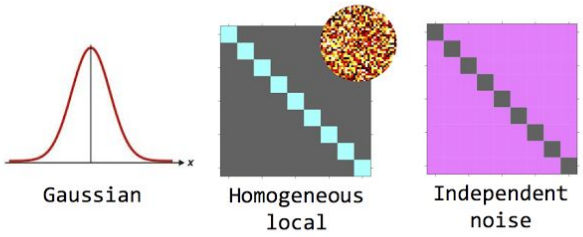
SPM one sample t-test



FSL FLAME 1

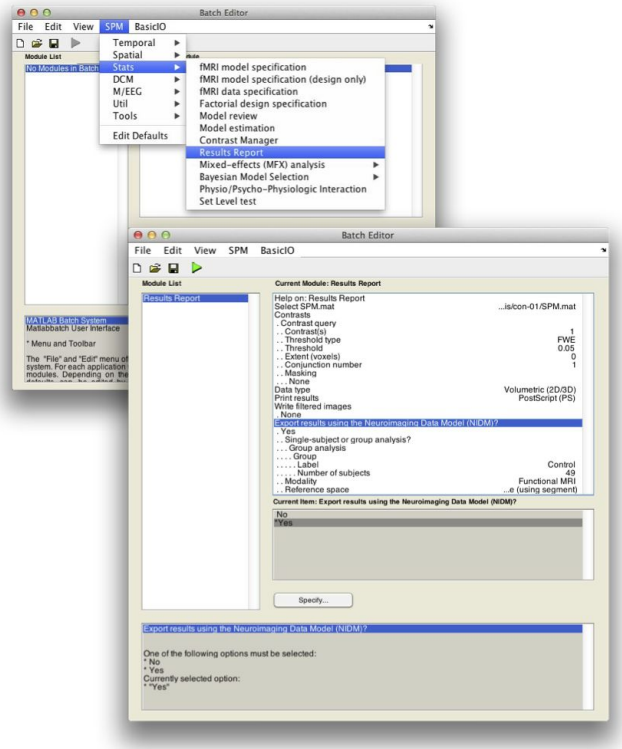


AFNI 3dttest++

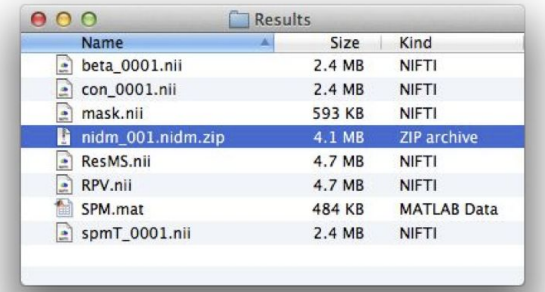


An image-based meta-analysis with NIDM-Results

SPM export to NIDM







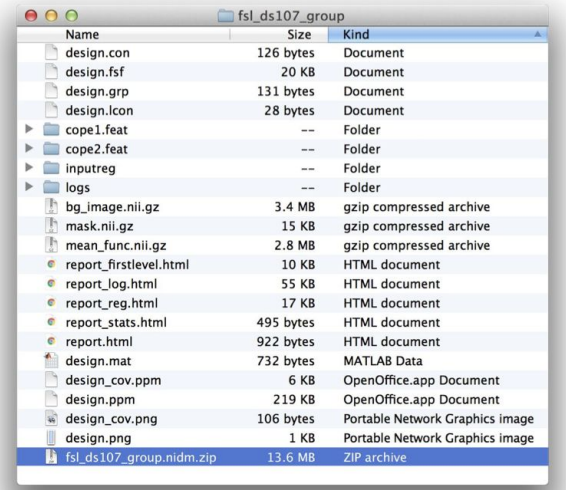
- Available as part of SPM12

www.fil.ion.ucl.ac.uk/spm/

FSL export to NIDM



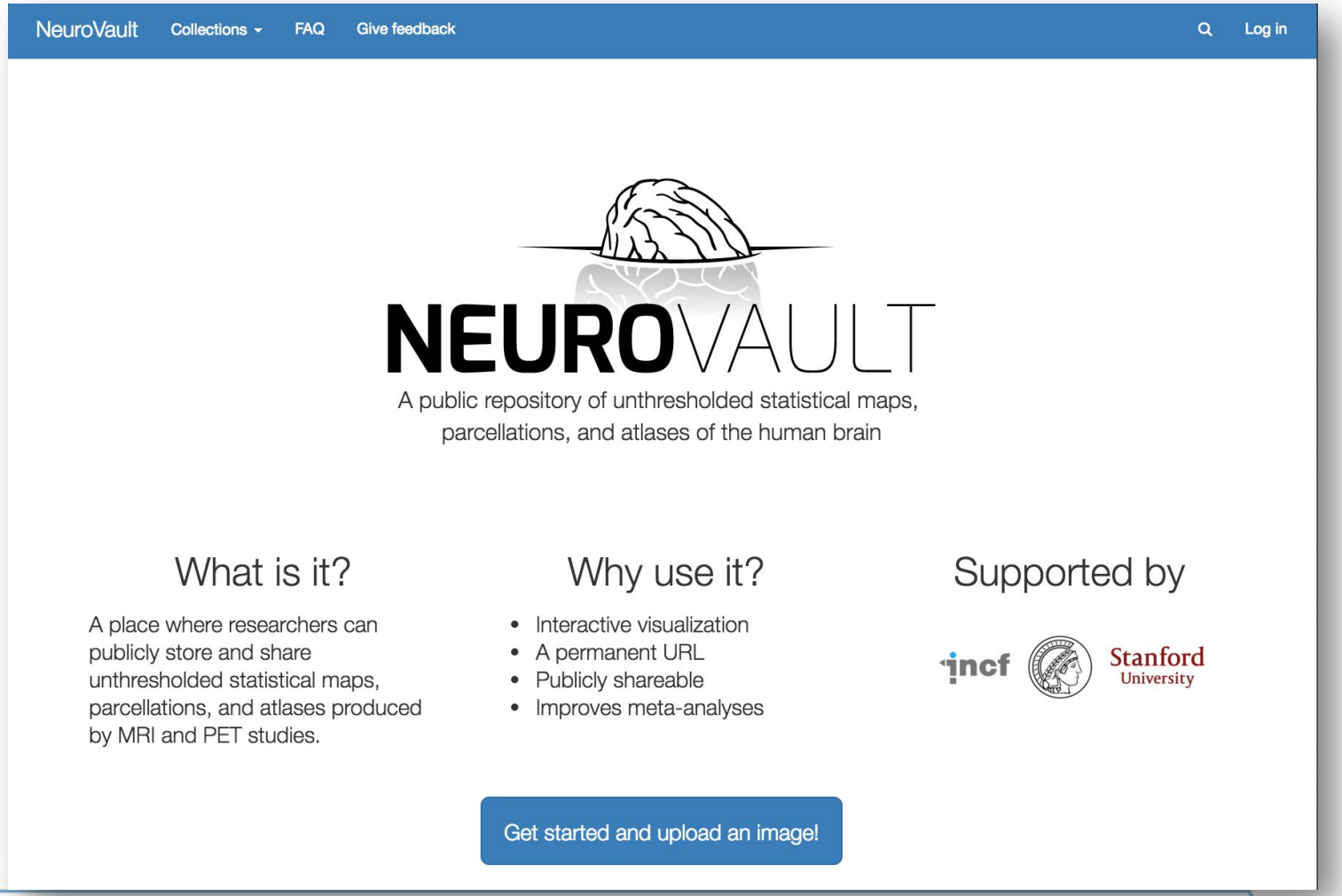
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$ nidmfsl ds107.gfeat -g Control 49
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- Install via `pip`
- To be included in the next FSL release

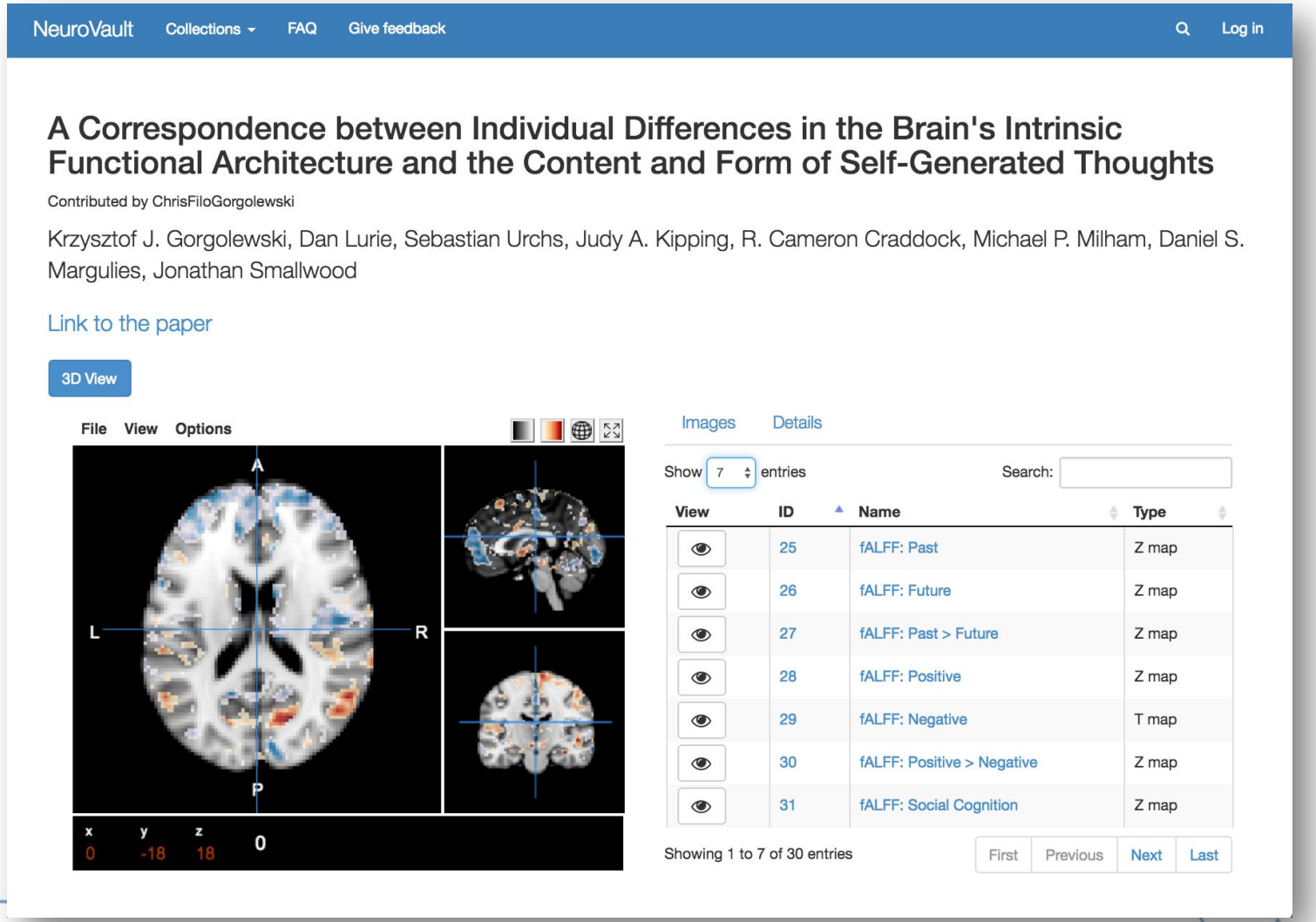
https://github.com/incf-nidash/nidmresults-fsl
http://fsl.fmrib.ox.ac.uk

Upload to NeuroVault



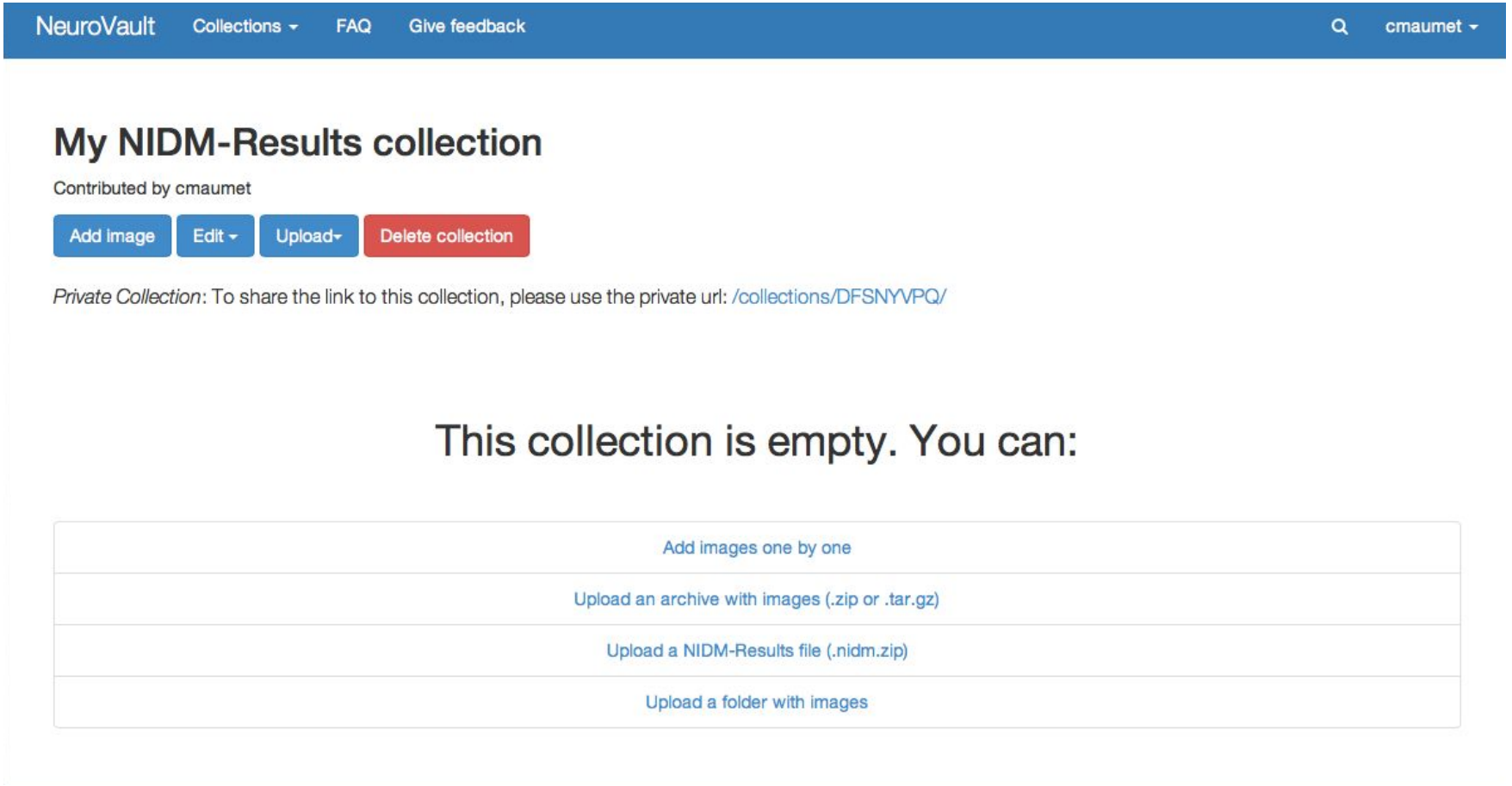
http://neurovault.org

Upload to NeuroVault



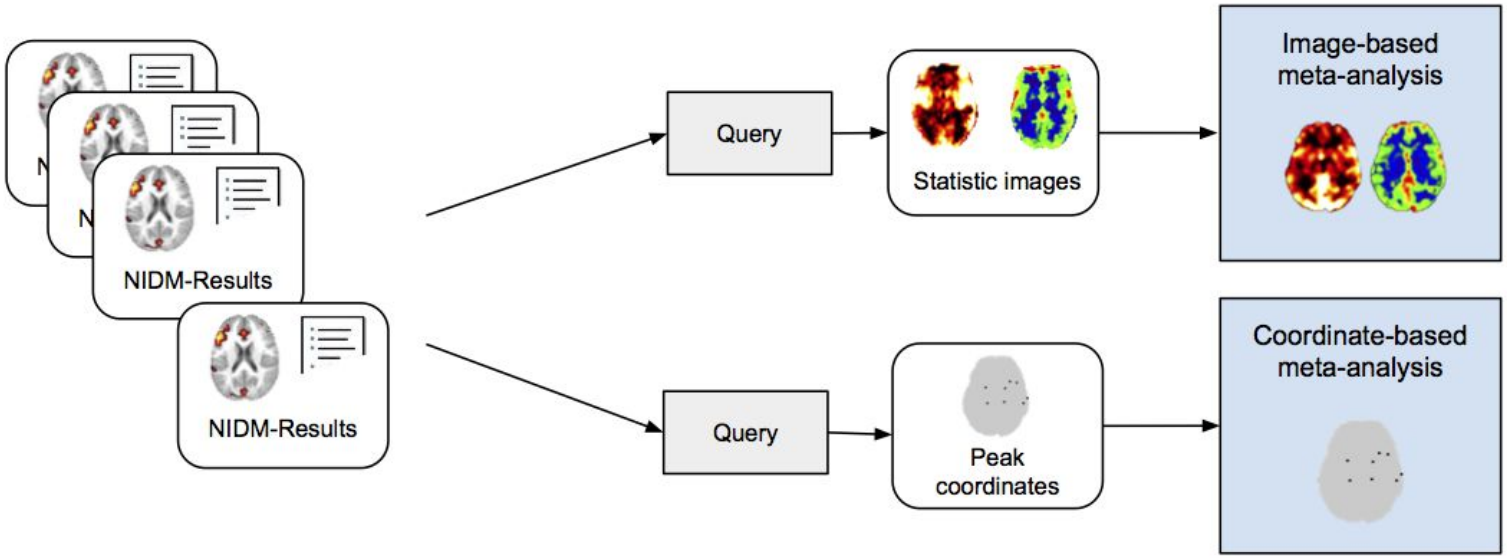
http://neurovault.org

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http://neurovault.org

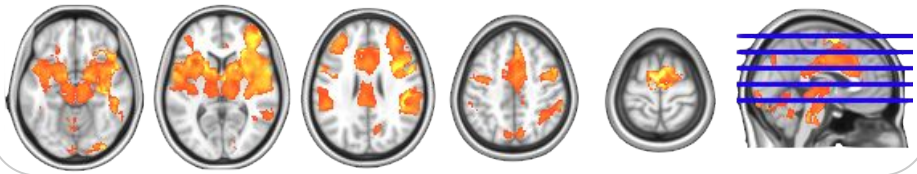
Example of meta-analysis



Coordinate-based meta-analysis



Image-based meta-analysis



Scripts available at http://github.com/incf-nidash/nidmresults-paper

Conclusion

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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 wellcome trust

Q & A

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https://github.com/incf-nidash

http://nidm.nidash.org