



Standardized reporting of neuroimaging results with NIDM

Jan. 26th 2015
University of California at Berkeley

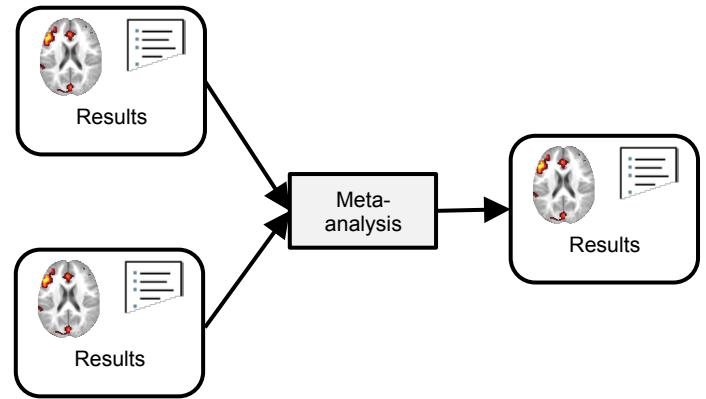
Camille Maumet

THE UNIVERSITY OF
WARWICK

Agenda

- Context
 - Meta-analysis in neuroimaging
 - NIDM and the INCF NIDASH Task force
 - Data sharing environment
- NIDM for meta-analysis
 - NIDM-Results
 - Implementation
 - Future directions
- Conclusions

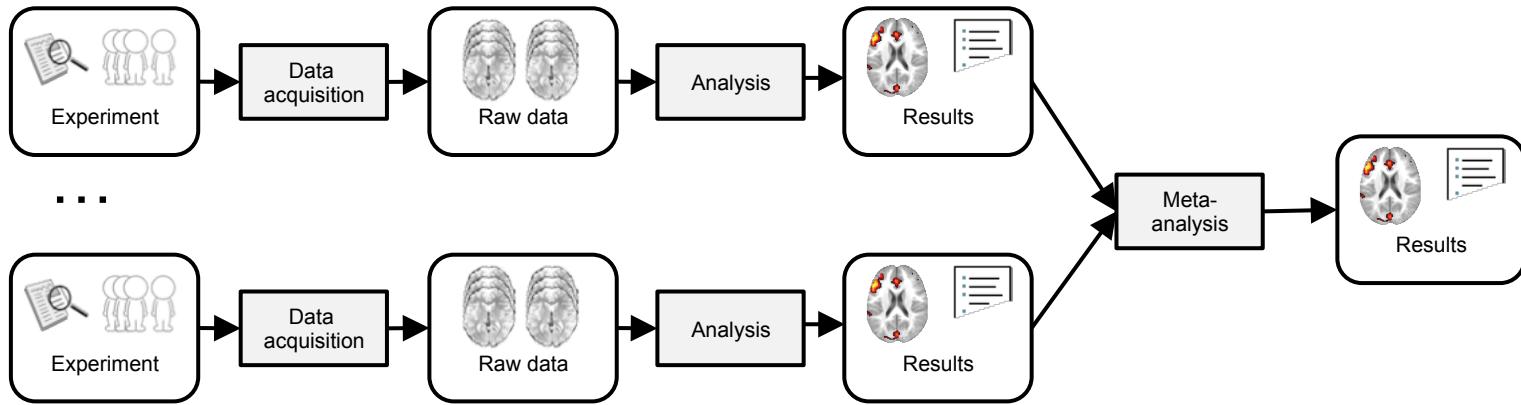
CONTEXT



CONTEXT

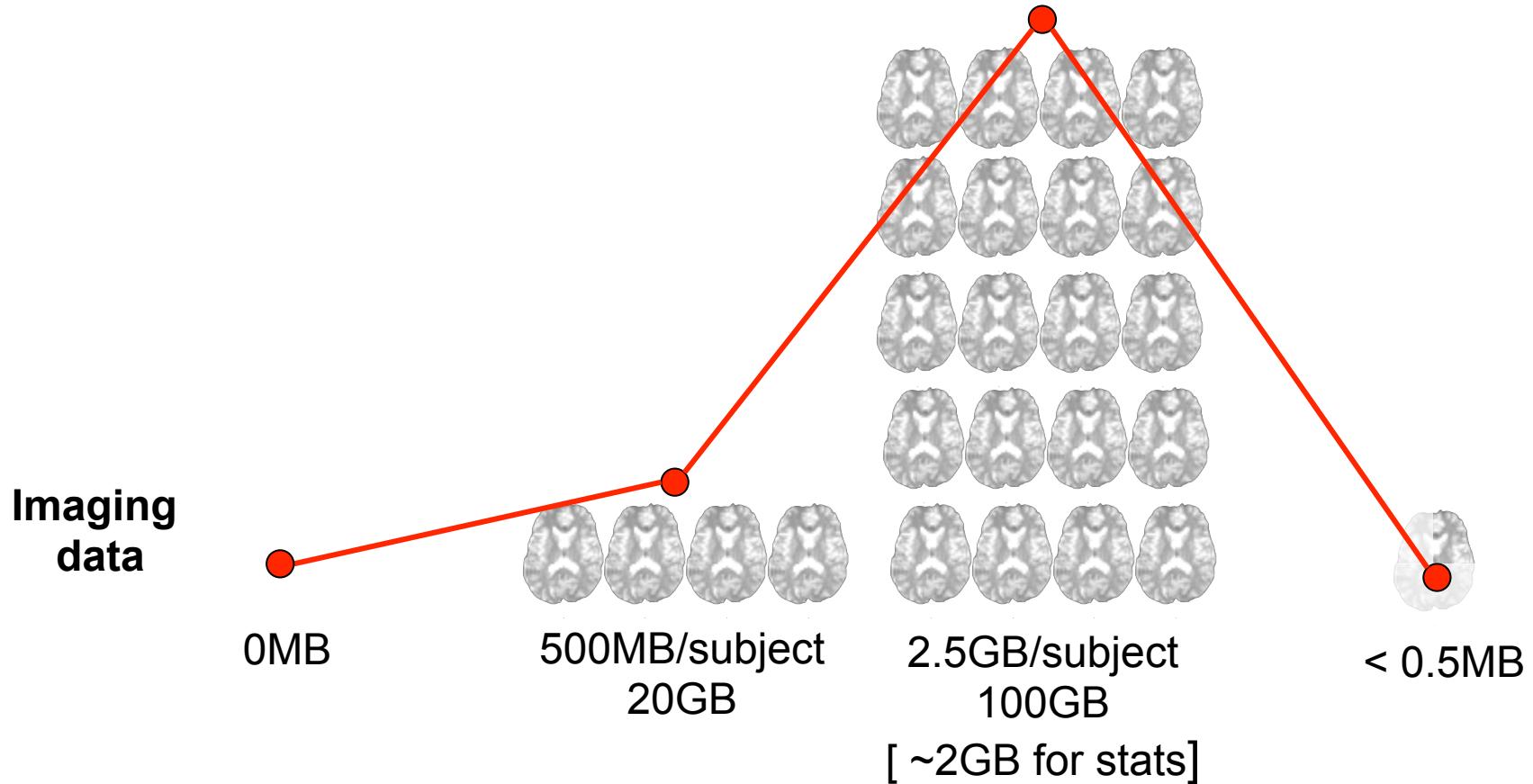
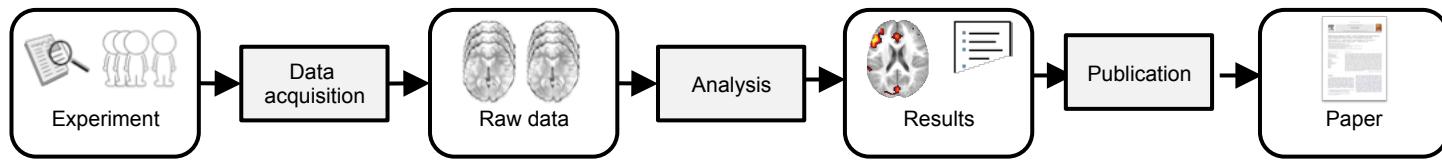
Meta-analysis in neuroimaging

Why meta-analyses?

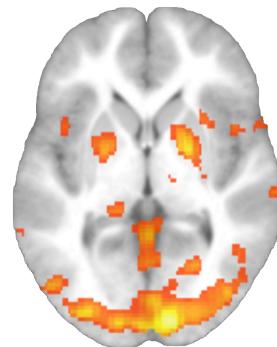
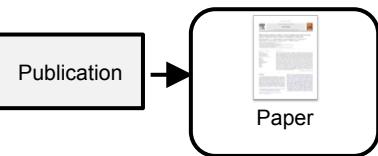


- Increase statistical power
- Combine information across studies

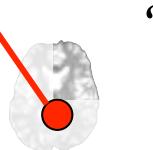
Data analysis in neuroimaging



Data analysis in neuroimaging



Detection images
(qualitative)



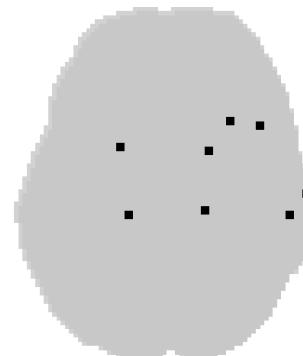
?

< 0.5MB

Table 2
Task comparisons (>) and conjunctions (C). Peak locations, cluster extent-Z-score ($p < 0.001$ unc.; $k = 10$).

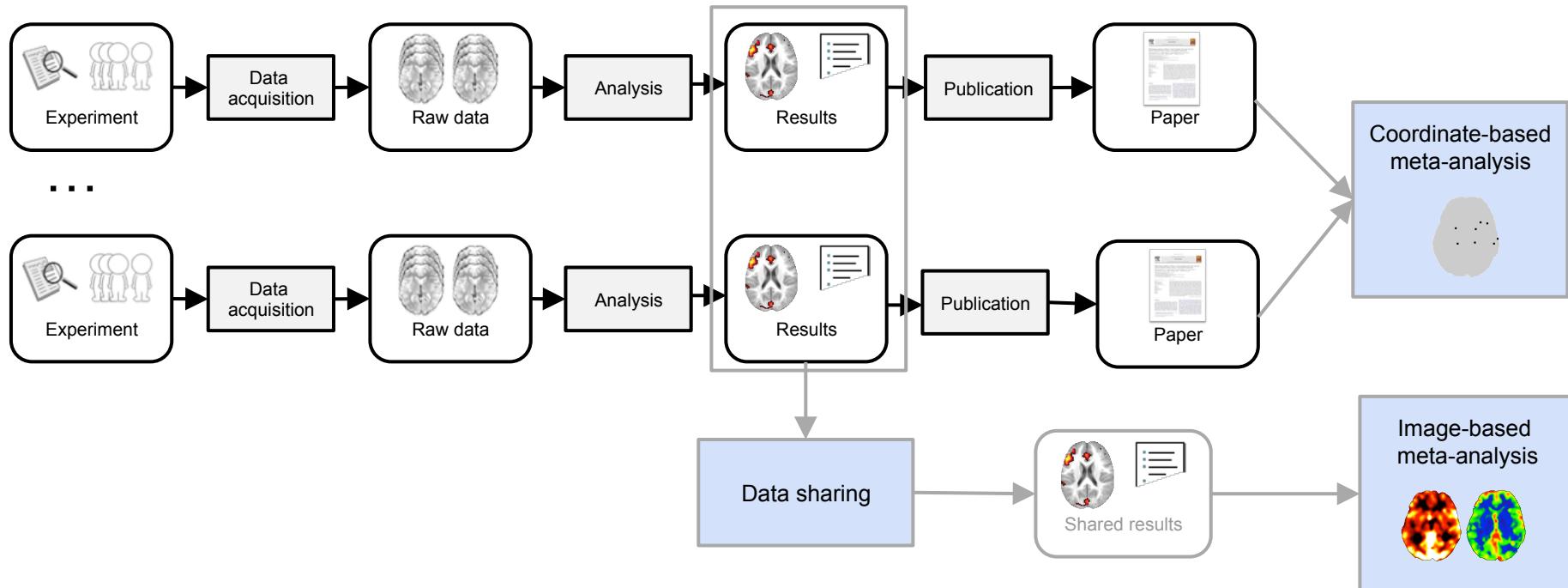
	Auditory language tasks			Visual language tasks	
	Categ>Def	Def>Categ	Categ C Def	Ph-s>Ph-d	Ph-
<i>Left Hemisphere</i>					
Inf frontal-Oper	--	--	348–4.10 ⁽⁴⁾	--	82 ^a
Precentral	18–3.38 ⁽⁵⁾	--	348–5.09	--	82 ^a
Mid frontal	33–3.66	--	--	--	--
SMA	--	--	1433–5.48	--	35 ^c
Cingulate	--	--	1433–5.08 ⁽³⁾	--	--
Med sup frontal	174–4.69	--	--	--	--
Rol operculum	--	--	--	36 – 4.31	--
Insula	--	--	396–4.87 ⁽⁸⁾	--	58–
Sup temporal	--	--	351–3.81 ⁽¹⁾	--	91–
Mid temporal	--	1658–4.67 ⁽³⁾	351–5.61 ⁽²⁾	--	10–
Inf parietal	--	1658–5.18 ⁽⁶⁾	--	--	--
Sup parietal	--	--	--	--	97 ^c
Postcentral	--	--	--	--	97 ^c
Sup occipital	--	--	--	--	--
Mid occipital	--	--	--	146–4.43	14 ^c
Inf occipital	--	--	--	--	14 ^c
Fusiform	--	--	--	397–5.44	14 ^c

Table of local maxima
(quantitative)

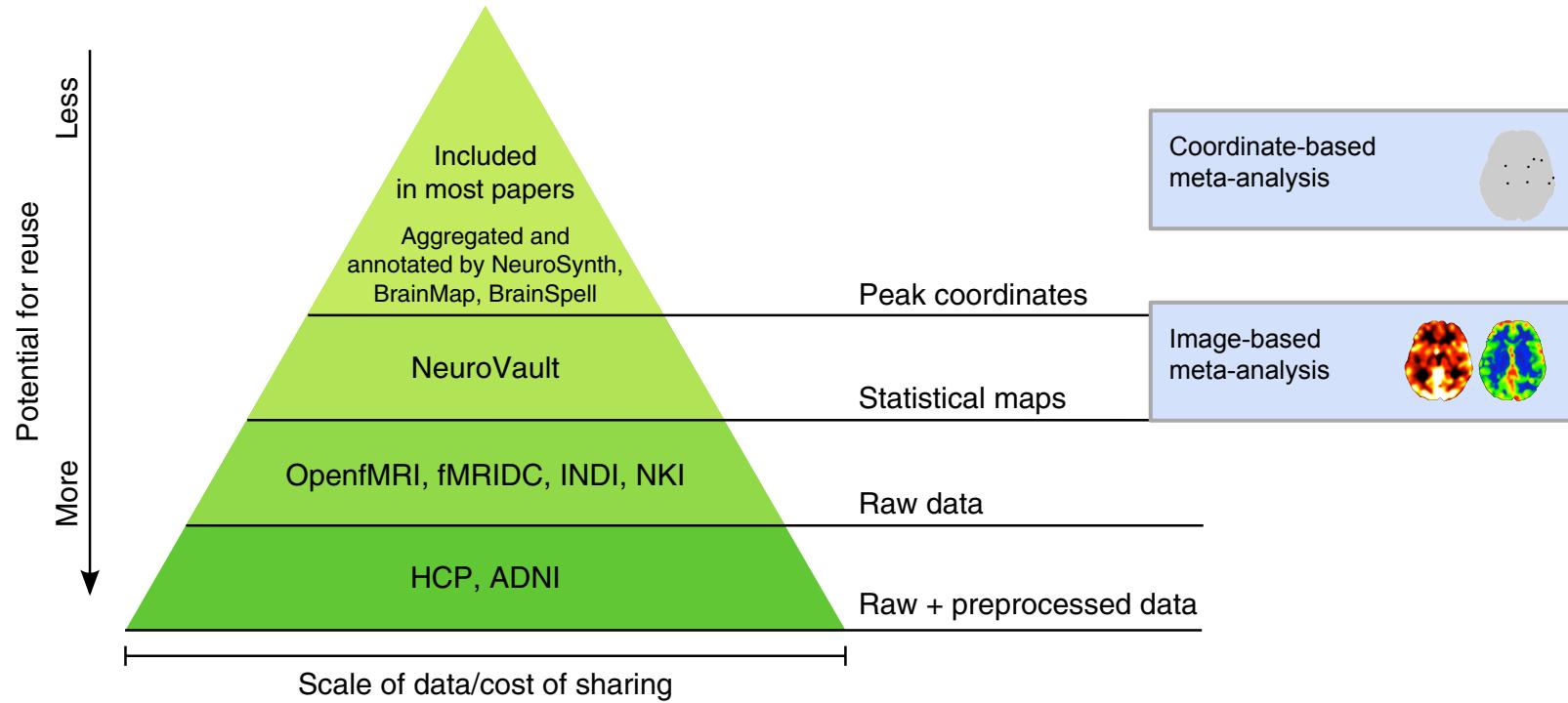


Peaks
(quantitative)

Coordinate- or Image-Based meta-analysis?



Which data to share?



Reprinted by permission from Macmillan Publishers Ltd: Nature neuroscience (Poldrack, R. a, & Gorgolewski, K. J. (2014). Making big data open : data sharing in neuroimaging. Nature Neuroscience, 17(11). doi:10.1038/nn.3818), copyright (2014)



CONTEXT

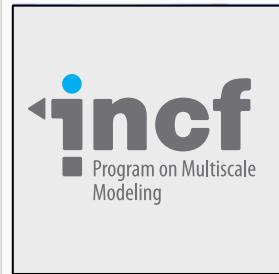
INCF NIDASH Task Force

International Neuroinformatics Coordinating Facility



Digital Brain Atlasing

Coordinates and improves the impact of brain atlasing projects



Multiscale Modeling

Improves interoperability and reproducibility of neural simulations



Ontologies of Neural Structures

Establishes consistent naming and classification for all neural structures



Standards for Data Sharing

Develops metadata and data standards for reproducible research



2 Task Forces

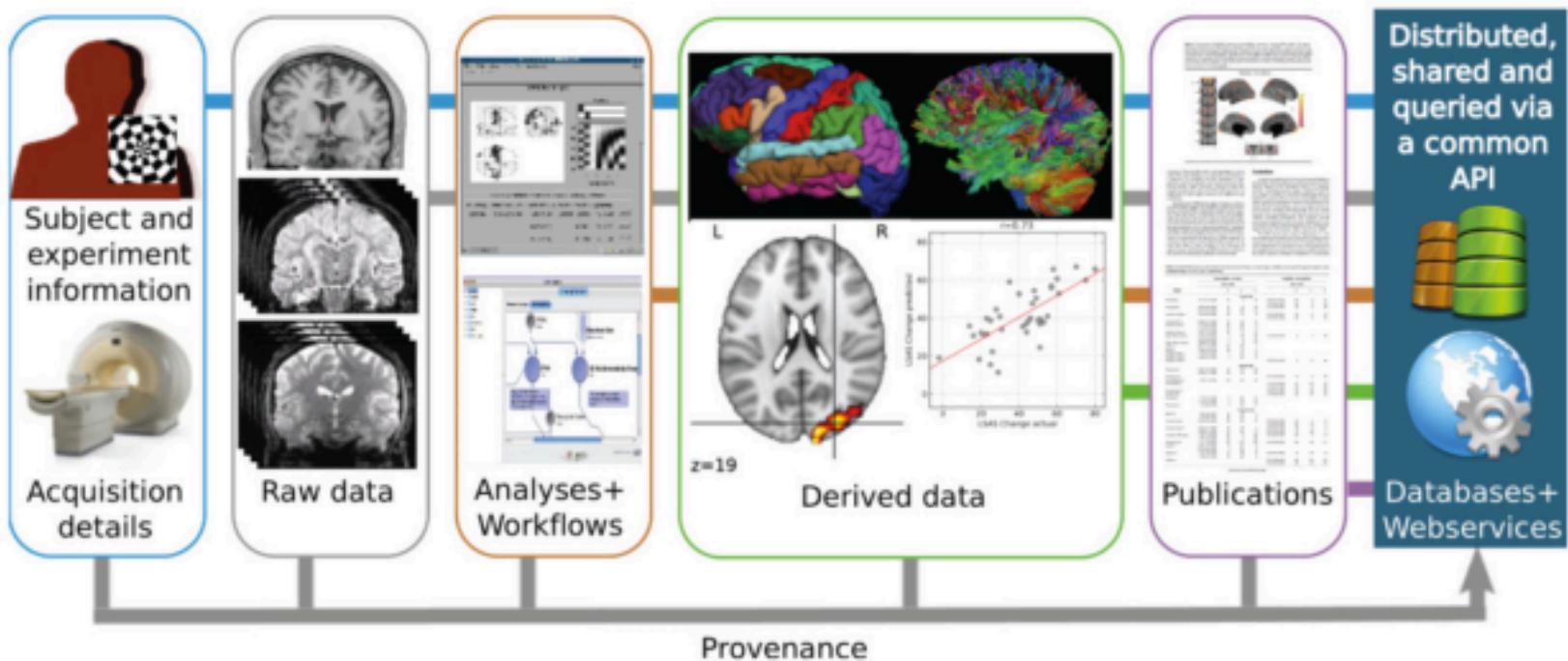
- Neuroimaging (NIDASH)
- Electrophysiology

NIDM working group

- NIDASH Task force
 - “Standards for Data Sharing aims to develop **generic standards and tools** to facilitate the **recording, sharing, and reporting of neuroscience metadata**, in order to improve practices for the **archiving and sharing of neuroscience data**.”
- BIRN Derived Data Working Group

NIDM: Neuroimaging Data Model

Stages of Electronic Data Capture

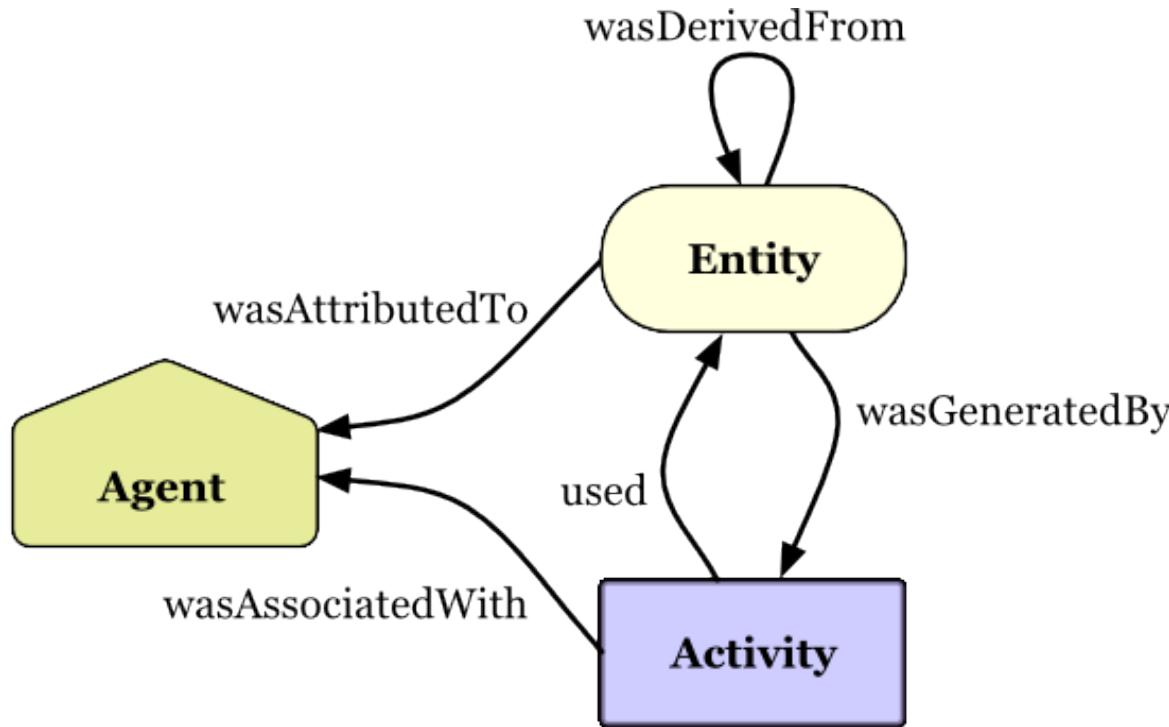


| Electronic Data Capture (EDC) workflow for data sharing in neuroimaging research.

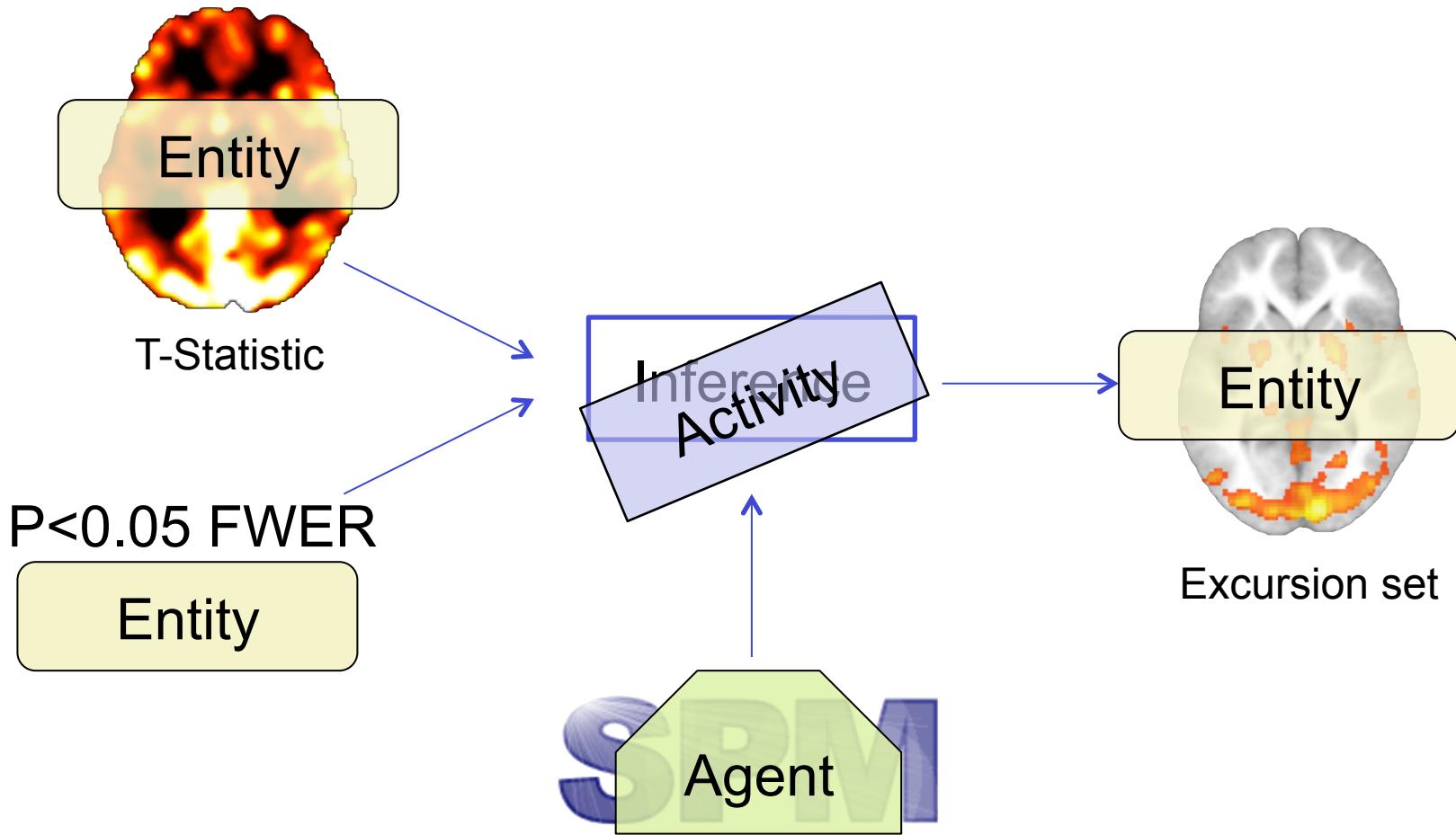
Source: Poline et al, *Frontiers in Neuroinformatics* (2012).

NIDM: Neuroimaging Data Model

- Based on PROV-DM



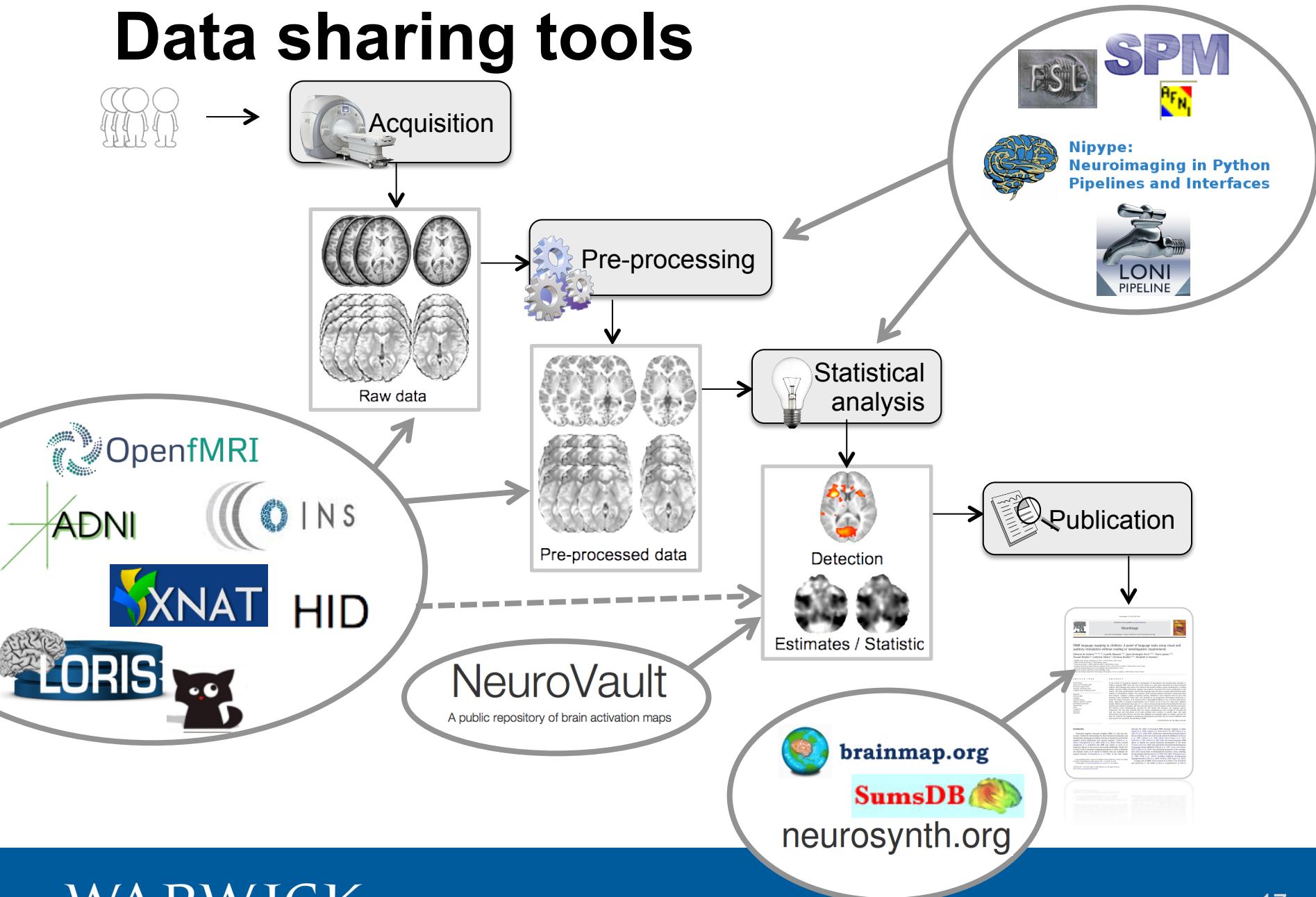
PROV-DM example



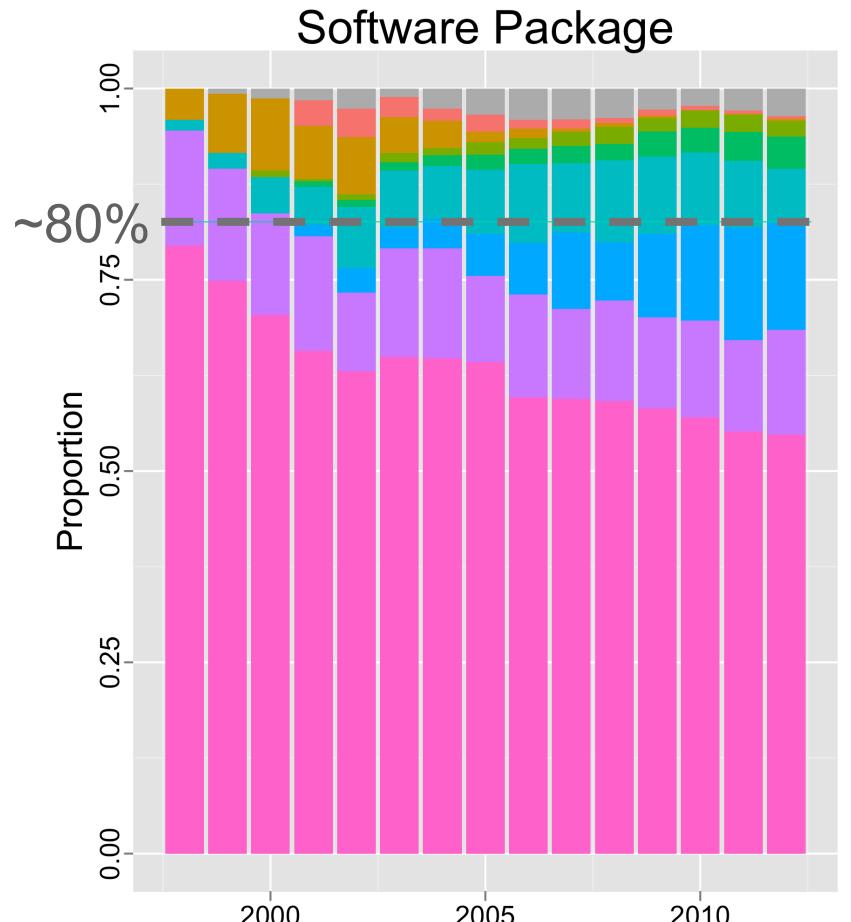
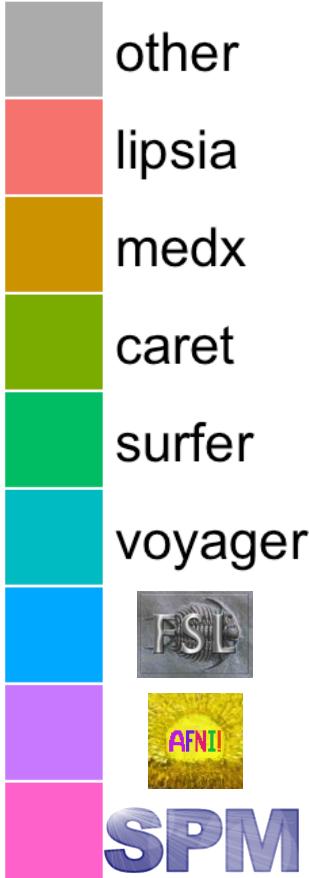
CONTEXT

Data sharing environment

Data sharing tools



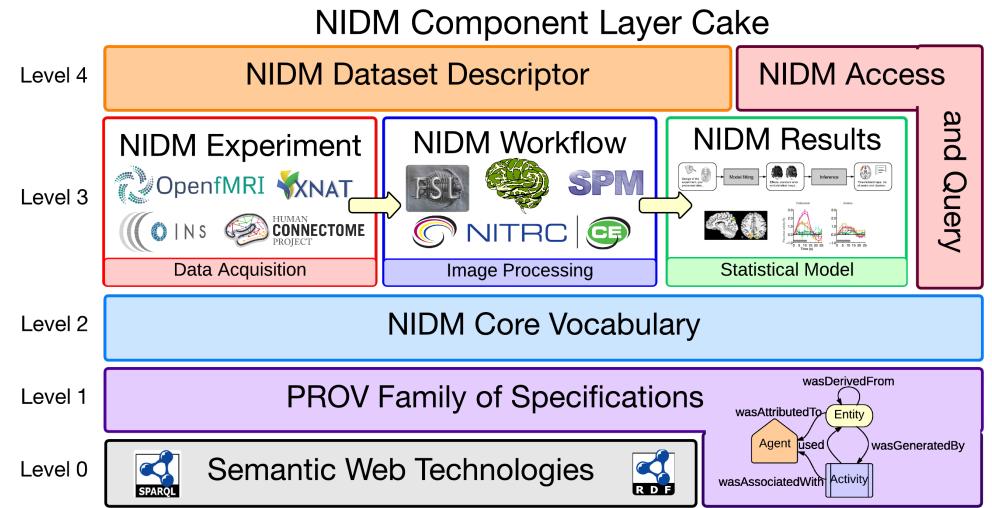
Three major software packages



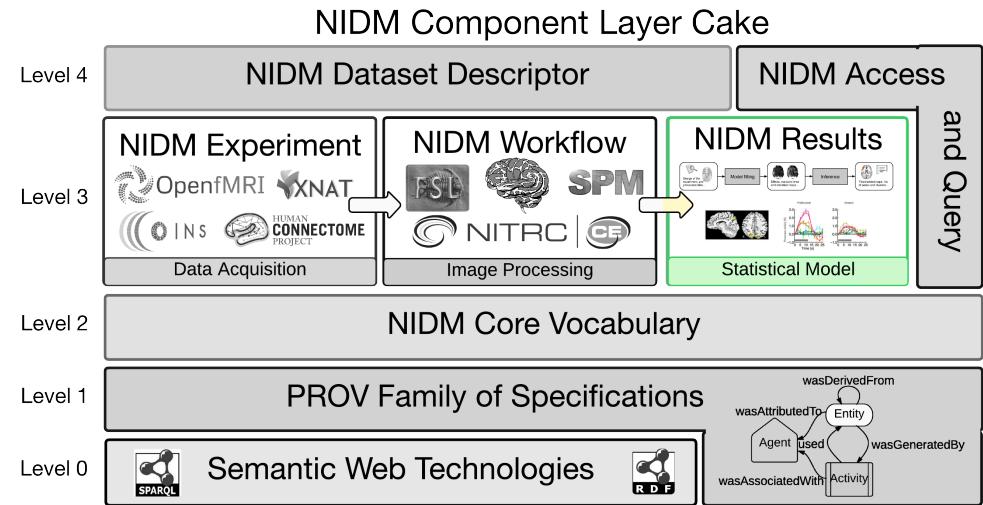
Automatically created with [Neurotrends](#) based on over
16 000 journal articles; Source:
<http://neurotrends.herokuapp.com/static/img/temporal/pkg-prop-year.png>

Summary of the problem

- Use-case: Support meta-analysis
- Machine-readable format describing neuroimaging results
- Easiness for the end-user
- Integrate with existing neuroimaging software packages (SPM, FSL, AFNI,...)
- Extend previous work: NIDM



NIDM FOR META-ANALYSIS

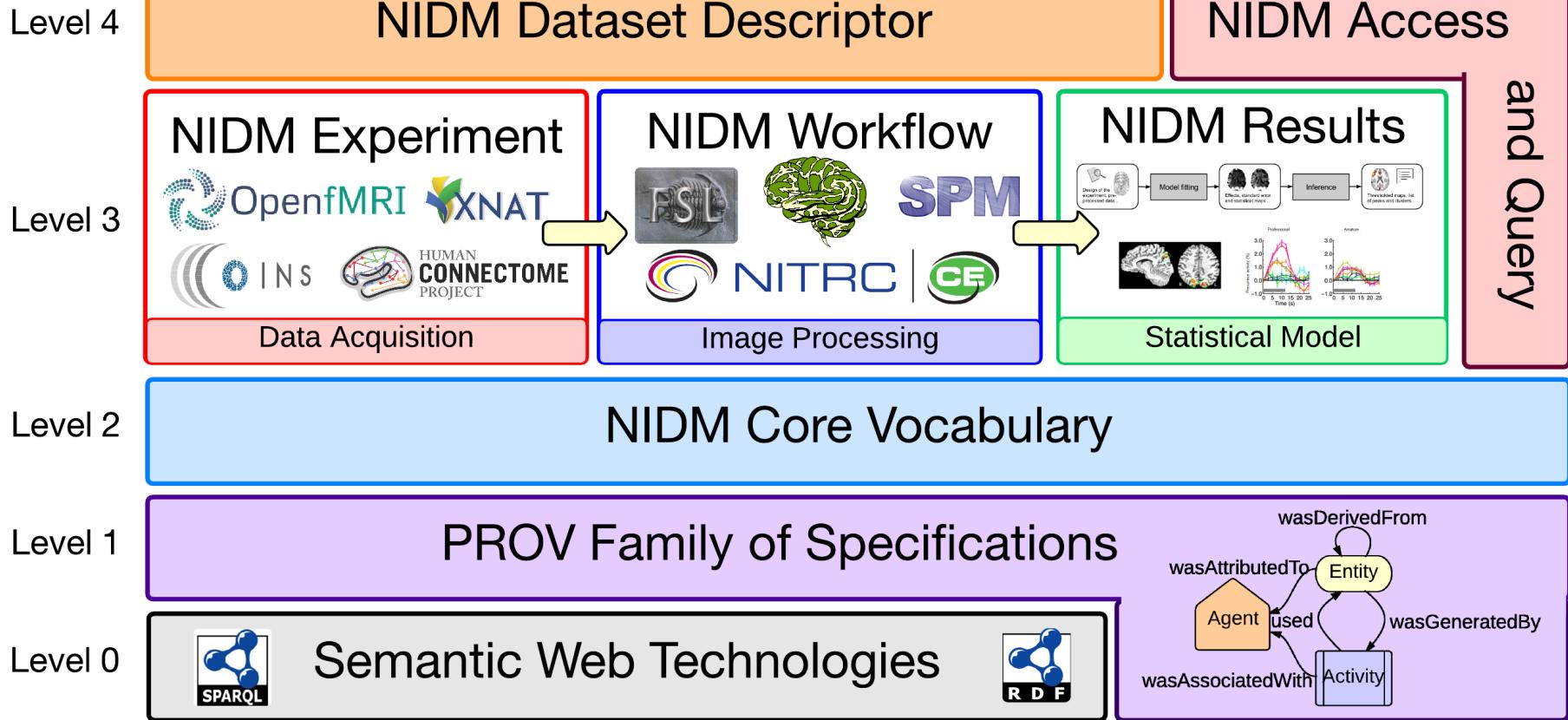


NIDM FOR META-ANALYSIS

NIDM-Results

Neuroimaging Data Model

NIDM Component Layer Cake



NIDM-Results

NIDM Component Layer Cake

Level 4

NIDM Dataset Descriptor

NIDM Access

NIDM Experiment



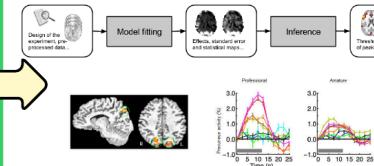
Data Acquisition

NIDM Workflow



Image Processing

NIDM Results



Statistical Model

and Query

Level 3

Level 2

NIDM Core Vocabulary

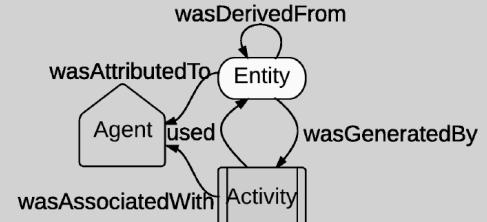
Level 1

PROV Family of Specifications

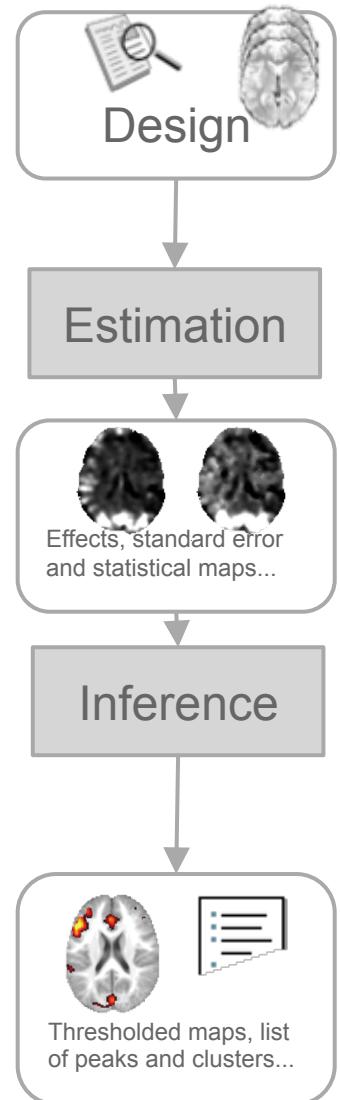
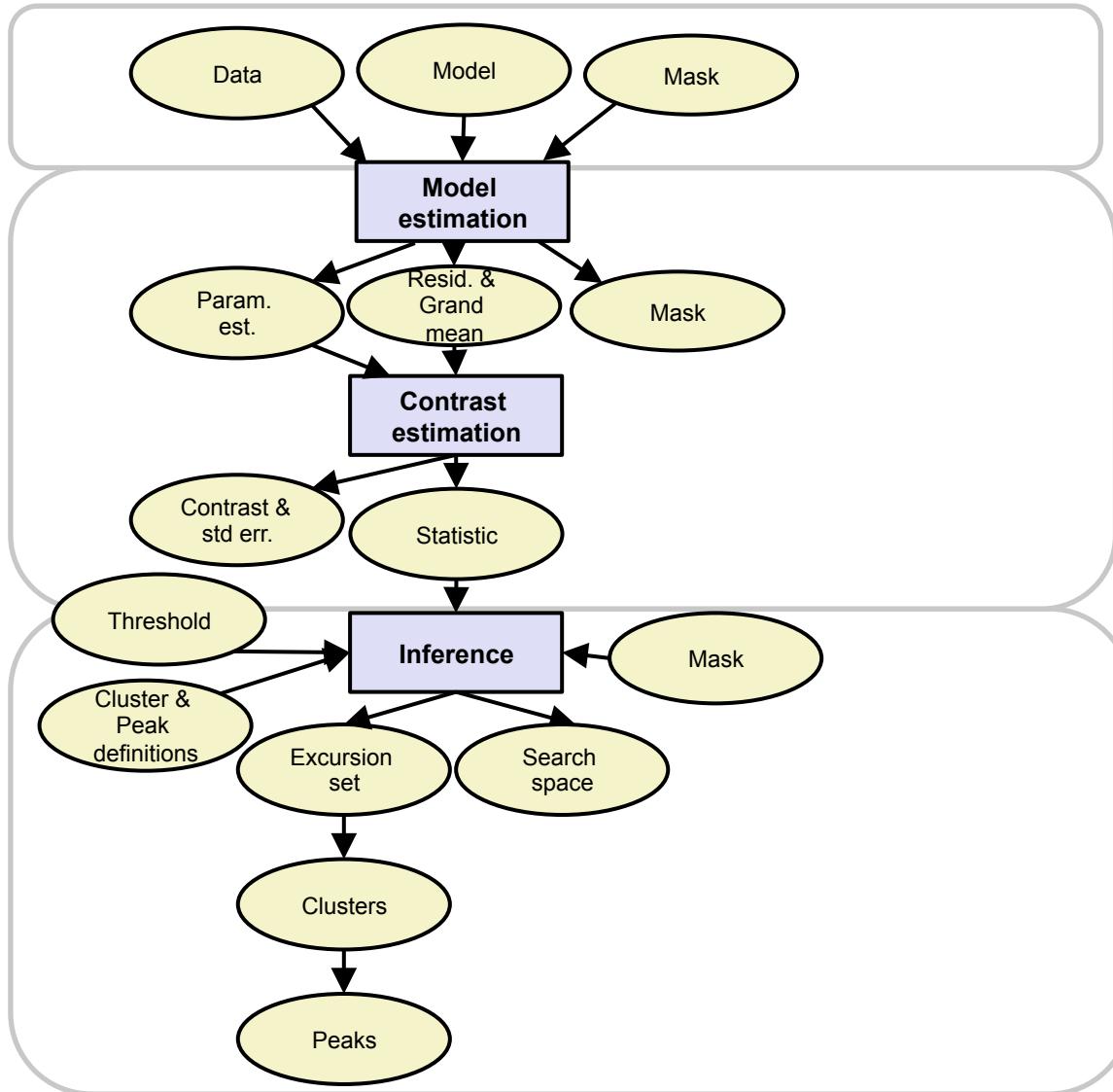
Level 0



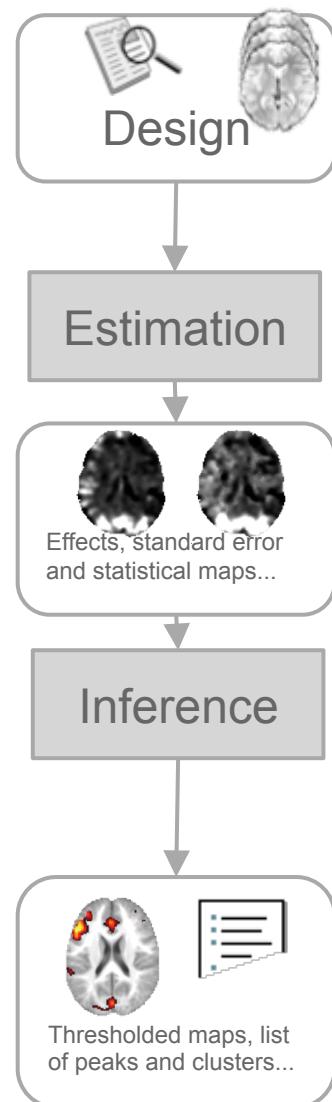
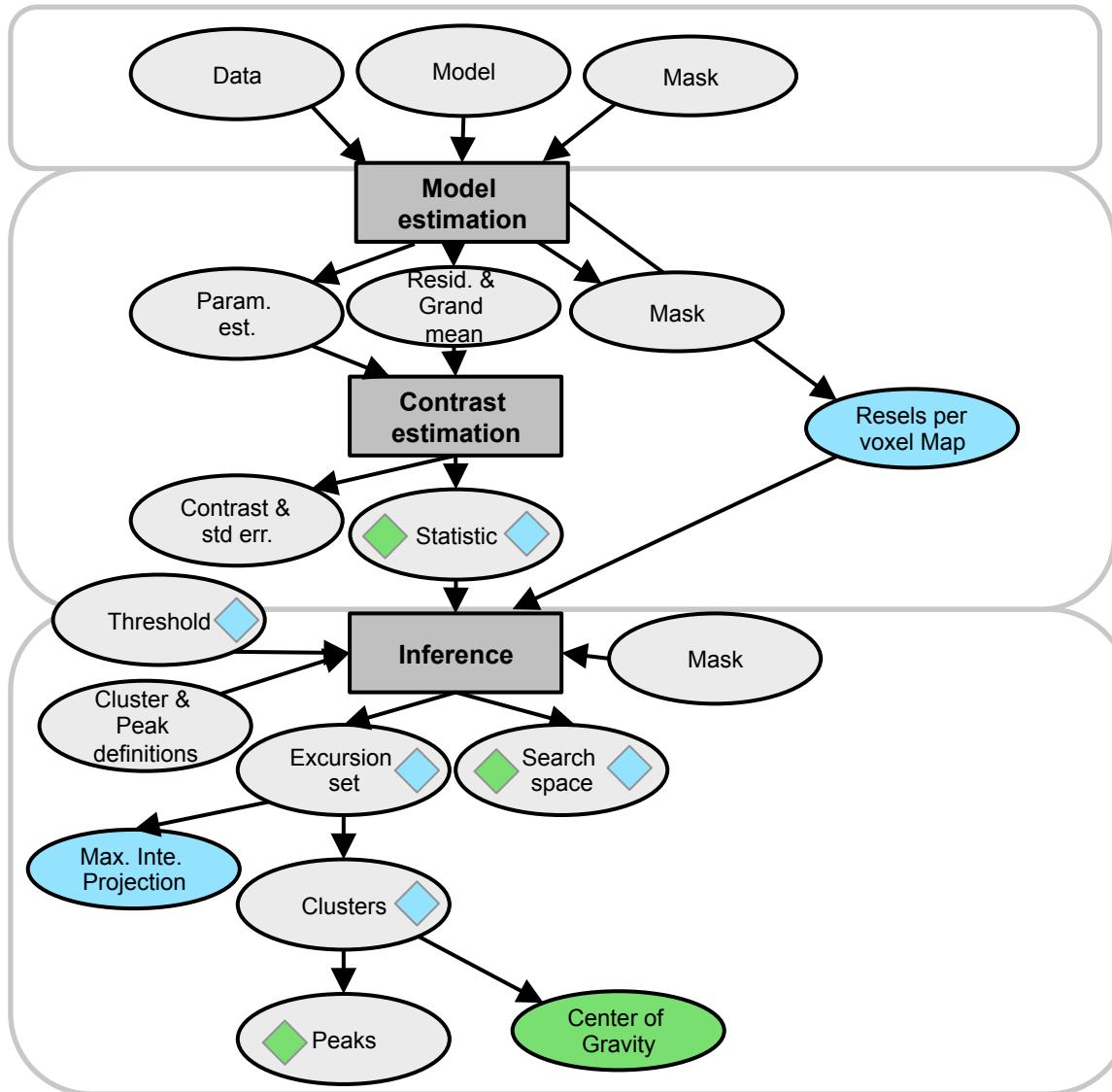
Semantic Web Technologies



NIDM-Results

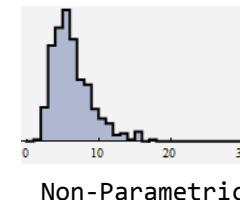
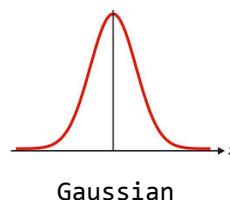


NIDM-Results: software-specific extensions

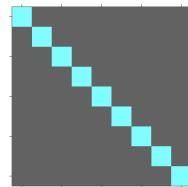


Standardization across software

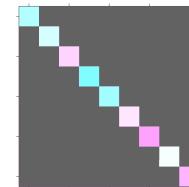
- Model of the error
 - Prob. distribution:
 - Variance:
 - Dependence:



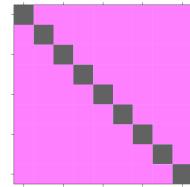
...



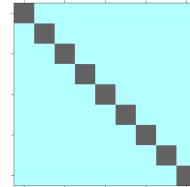
homogeneous



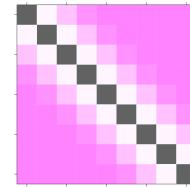
heterogeneous



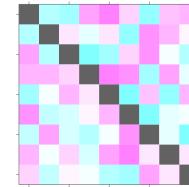
Independent noise



Compound Symmetry



Serially correlated



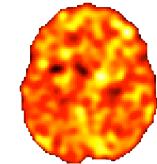
Arbitrarily correlated



global



local

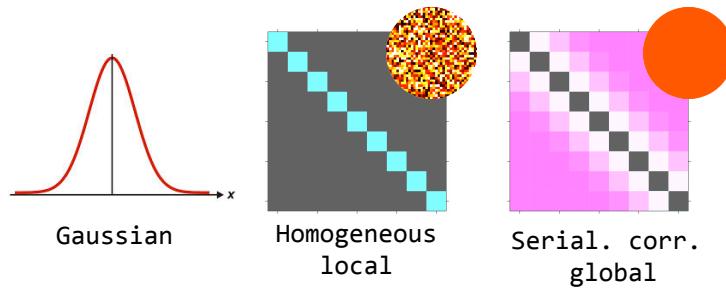


regularized

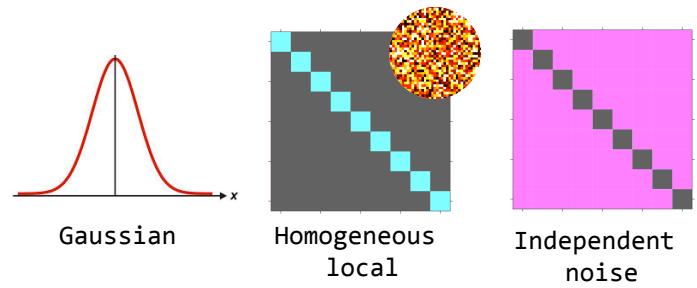
Error models : SPM, FSL and AFNI

SPM

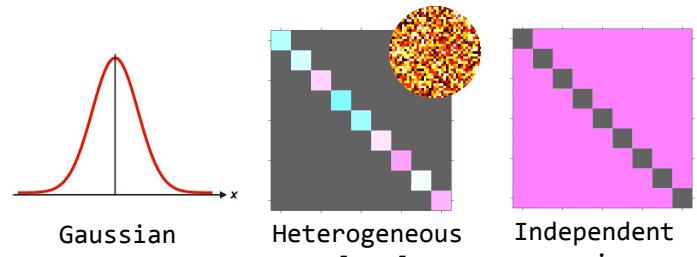
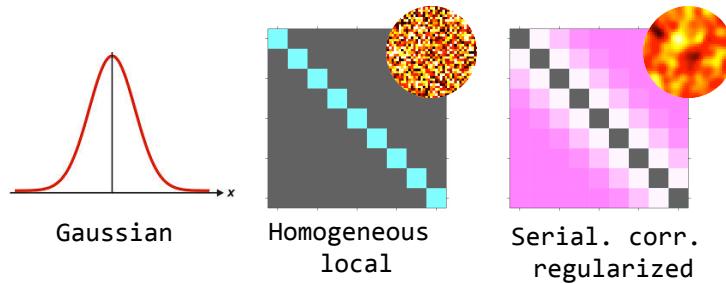
1st level



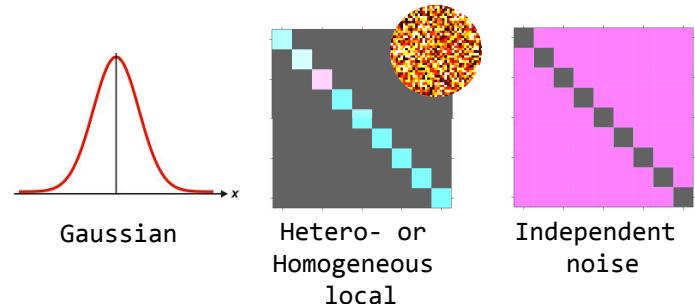
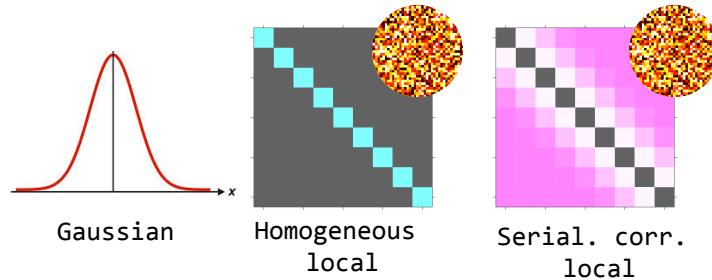
2nd level



FSL



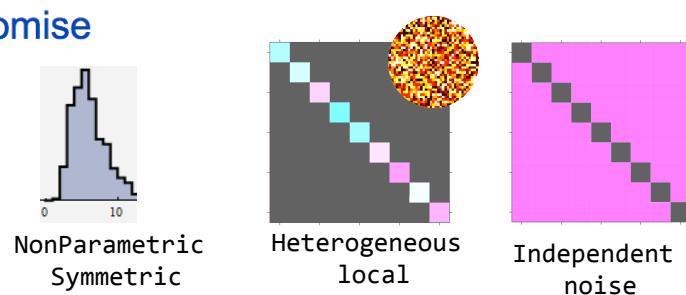
AFNI



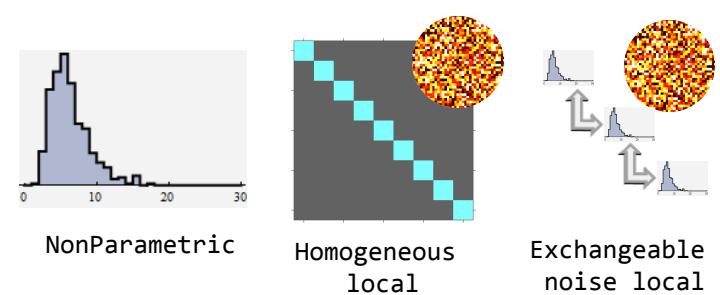
Error models: non-parametric



2nd level: Sign-flipping



2nd level: Label permutation



Terms

- Terms re-use:
 - Close interaction with STATO (Statistics terms)
 - Dublin Core (file formats)
 - But also: NCIT, OBI...
- Work-in-progress
 - <https://github.com/ncf-nidash/nidm/>
- Aim: include the created terms in Neurolex.

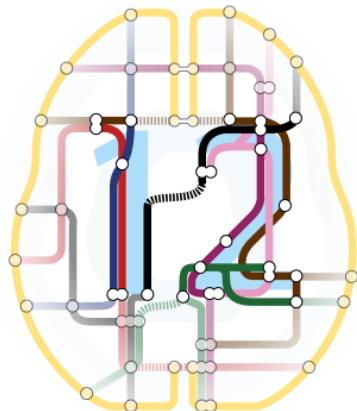


NIDM FOR META-ANALYSIS

Implementation

Implementation

- NIDM export
 - SPM12 (natively)
 - Scripts for FSL:
https://github.com/incf-nidash/nidm-results_fsl
 - In collaboration with AFNI developers:
https://github.com/incf-nidash/nidm-results_afni



NIDM FOR META-ANALYSIS

Future directions

Next steps and future plans

- Extend NIDM-Results implementation:
 - AFNI
 - SnPM, Randomise
- Refine the terms and definitions.



Next steps and future plans

- NIDM import for Neurovault

NeuroVault (beta) Add new collection See all collections FAQ Give feedback Log in

NeuroVault

A public repository of unthresholded brain activation maps

What is it?
A place where researchers can publicly store and share unthresholded statistical maps produced by MRI and PET studies.

Why use it?

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

Supported by



Get started and upload an image!

Latest collections of images

Name	Number of images
Altered functional connectivity in posttraumatic stress disorder with versus without comorbid major depressive disorder: a resting state fMRI study	4
Structural and functional MRI study of the brain, cognition and mood in long-term adequately treated Hashimoto's thyroiditis	2
please affects frontoparietal and cerebellar hubs in close correlation with clinical symptoms—a resting-	6

NeuroVault (beta) Add new collection See all collections FAQ Give feedback cmaumet ▾

Add new collection

A collection is a set of images grouped together for some sensible reason. Most commonly, a collection contains all of the images from a single study. Please provide information about this collection. Only the starred fields* are mandatory, but please try to provide as much information as you can.

Essentials Subjects Design Acquisition Registration Preprocessing 1st Level 2nd Level

Type of design Blocked, event-related, hybrid, or other

No. of imaging runs Number of imaging runs acquired

No. of experimental units Number of blocks, trials or experimental units per imaging run

Length of runs Length of each imaging run in seconds

Length of blocks For blocked designs, length of blocks in seconds

Length of trials Length of individual trials in seconds

Optimization? Unknown Was the design optimized for efficiency

Optimization method What method was used for optimization?

Save

NIDM effort

NIDM Component Layer Cake

Level 4

NIDM Dataset Descriptor

NIDM Access

Level 3

NIDM Experiment



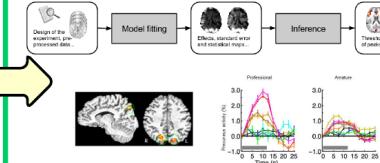
Data Acquisition

NIDM Workflow



Image Processing

NIDM Results



Statistical Model

Level 2

NIDM Core Vocabulary

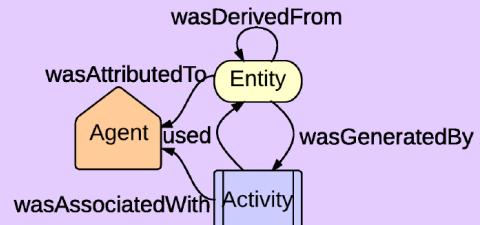
Level 1

PROV Family of Specifications

Level 0



Semantic Web Technologies



CONCLUSION

Conclusion

- NIDM-Results: standardized reporting of neuroimaging results
 - Use-case: Meta-analysis
 - Discussions: <https://github.com/incf-nidash/nidm>
 - Specification: <http://nidm.nidash.org>
 - Implementation in SPM12, FSL & (AFNI)
- Next steps
 - Refine the terms, AFNI and SnPM/Randomise models
 - Build more apps
 - NIDM-experiment, NIDM-workflow

Resources

- Github: <https://github.com/incf-nidash>
- Specifications: <http://nidm.nidash.org>

2. Overview

This section introduces neuroimaging results concepts with informal explanations and illustrative examples (e.g. see [SPM results](#) structures, forming the essence of the results, from software-specific structures catering for more specific uses of results by different studies respectively presented in Section 2.1 and Section 2.2).

2.1 Domain covered by NIDM-Results

NIDM-Results is concerned with the modelling of model fitting and inference in the context of massively univariate analyses. Analyses involving other modalities (such as PET) and sequences (e.g. anatomical MRI through VBM) can also be modelled. The domain is represented in .



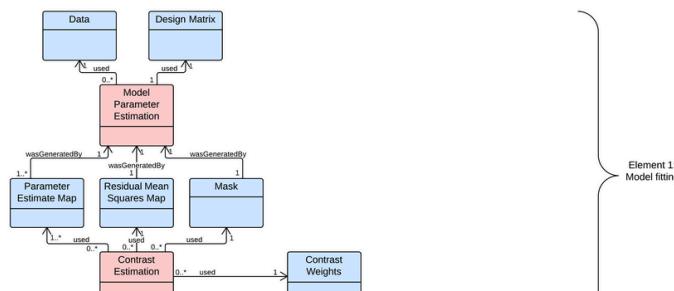
Fig. 2 Domain overview

2.2 NIDM-Results Core Structures

The concepts found in the core of NIDM-Results are introduced in the rest of this section.

2.2.1 Overview

The core NIDM-Results structures are presented in . The color coding corresponds to the prov:type (blue: prov:entity, red: prov: "Model fitting" and "Inference", the structures and relations belonging to each element are presented in details in and .



INCF-NIDASH
INCF Neuroimaging Data Sharing Task Force
nidm
Neuroimaging Data Model (NIDM): describing neuroimaging data and provenance
Updated 5 days ago

Create a definition for "Resel" #128
Definition of "ConjunctionInference" #134

NIDM-Results Terms curation status

Curation status: ■ PendingFinalVetting; ■ MetadataIncomplete; ■ RequiresDiscussion; ■ Uncurated; ■ ToBeReplacedByExternalOntologyTerm;

Curation Status	Term
■	fsl:ZStatisticMap: A map whose value at each location is a Z-statistic value.
■	nidm:ContrastMap: A map whose value at each location is statistical contrast estimate.

Acknowledgements



NIDM working group

Tibor Auer, Gully Burns, Fariba Fana, Guillaume Flandin, Satrajit Ghosh, Chris Gorgolewski, Karl Helmer, David Keator, Camille Maumet, Nolan Nichols, Thomas Nichols, Jean-Baptiste Poline, Jason Steffener, Jessica Turner.

INCF NIDASH - Other members

David Kennedy, Cameron Craddock, Stephan Gerhard, Yaroslav Halchenko, Michael Hanke, Christian Haselgrove, Arno Klein, Daniel Marcus, Franck Michel, Simon Milton, Russell Poldrack, Rich Stoner.

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

This work is supported by the

wellcome trust

Q & A

NIDM Resources

- Github: <https://github.com/incf-nidash>
- Specifications: <http://nidm.nidash.org>

Queries

- For each contrast get name, contrast file, statistic file and type of statistic used.

prefix prov: <<http://www.w3.org/ns/prov#>>

prefix nidm: <<http://www.incf.org/ns/nidash/nidm#>>

```
SELECT ?contrastName ?contrastFile ?statType ?statFile
```

WHERE {

```
?cid a nidm:ContrastMap ;
      nidm:contrastName ?contrastName ;
      prov:atLocation ?contrastFile .

?cea a nidm:ContrastEstimation .

?cid prov:wasGeneratedBy ?cea .

?sid a nidm:StatisticMap ;
      nidm:statisticType ?statType ;
      prov:atLocation ?statFile .
```

}

More queries: <http://tinyurl.com/nidm-results/query>

