Standardized reporting of neuroimaging results with NIDM

Jan. 26th 2015

University of California at Berkeley

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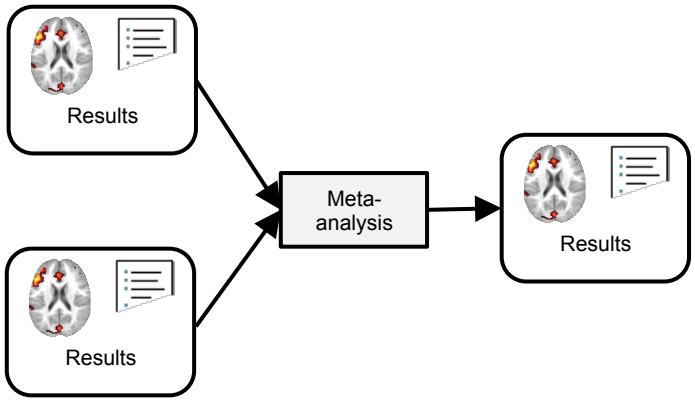
THE UNIVERSITY OF WARWICK

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

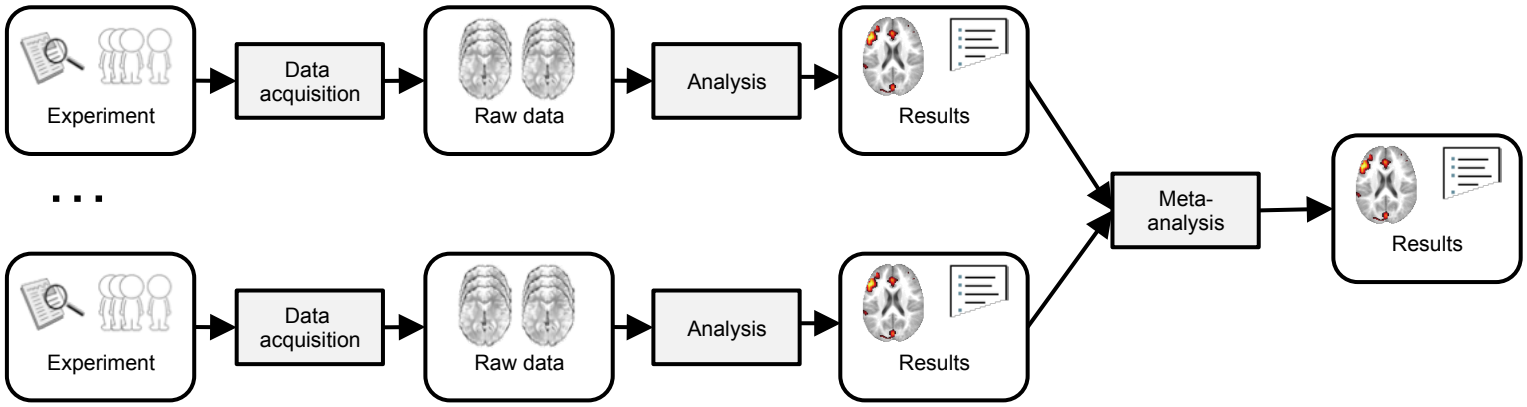
CONTEXT



CONTEXT

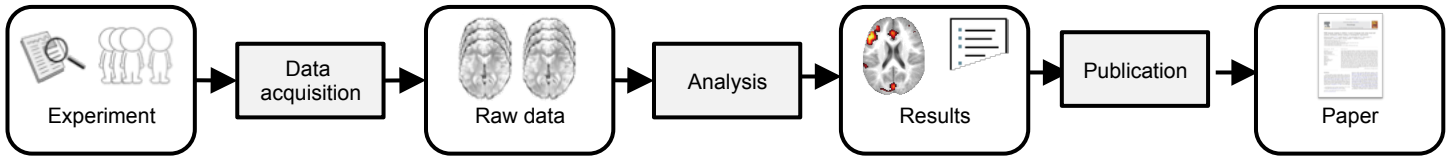
Meta-analysis in neuroimaging

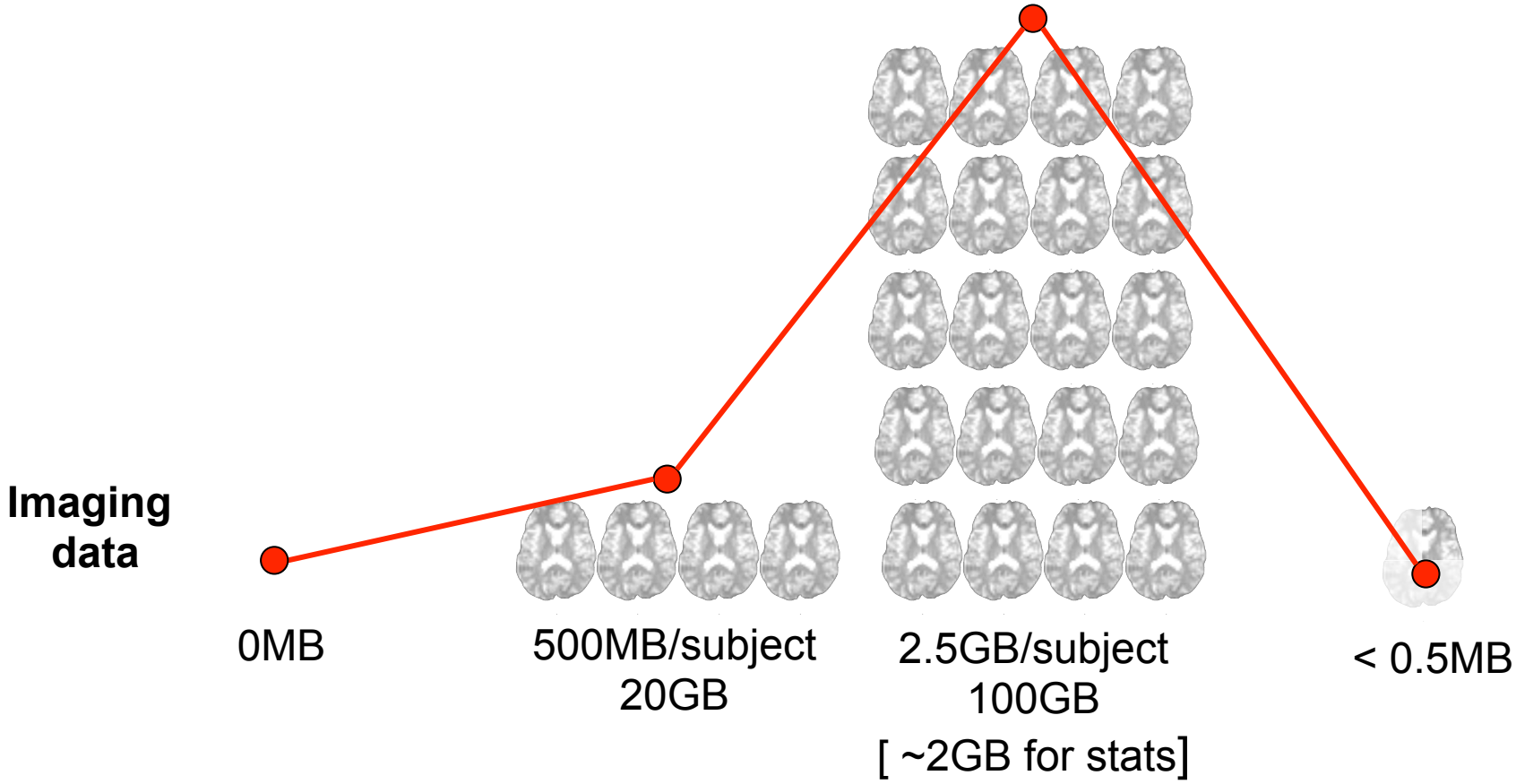
Why meta-analyses?



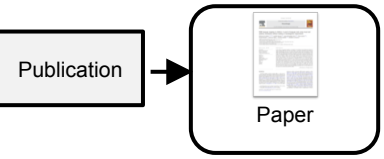
- Increase statistical power
- Combine information across studies

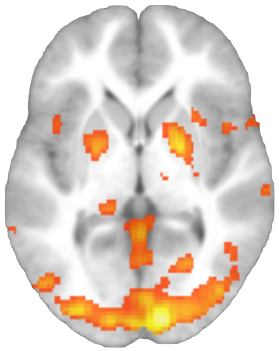
Data analysis in neuroimaging





Data analysis in neuroimaging



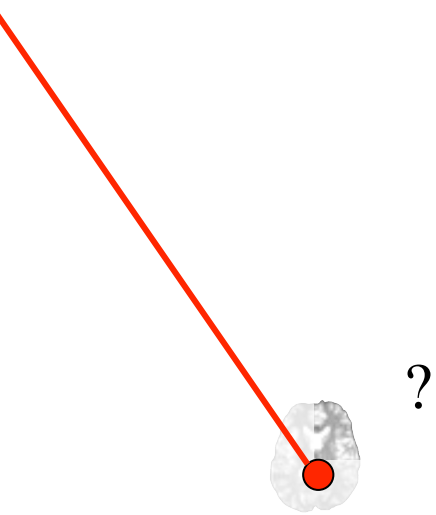


Detection images
(qualitative)

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-
Left Hemisphere					
Inf frontal-Oper	--	--	*348–4.10*(4)	--	*825*
Precentral	18–3.38(5)	--	348–5.09	--	825
Mid frontal	33–3.66	--	--	--	--
SMA	--	--	1433–5.48	--	357
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	--	--	--	--	976
Postcentral	--	--	--	--	*976*
Sup occipital	--	--	--	--	--
Mid occipital	--	--	--	146–4.43	*146*
Inf occipital	--	--	--	--	146
Fusiform	--	--	--	397–5.44	*146*

Table of local maxima
(quantitative)



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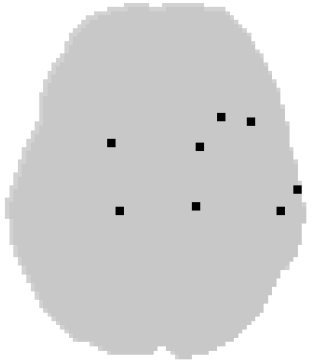
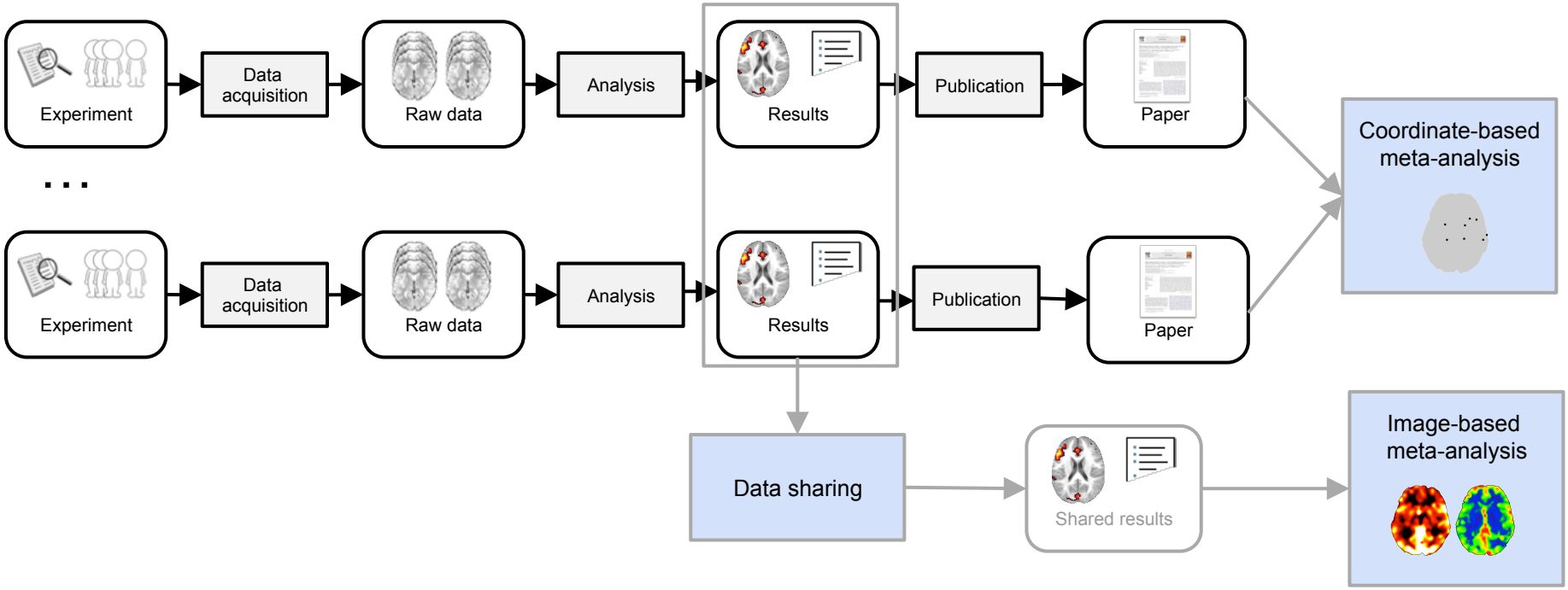
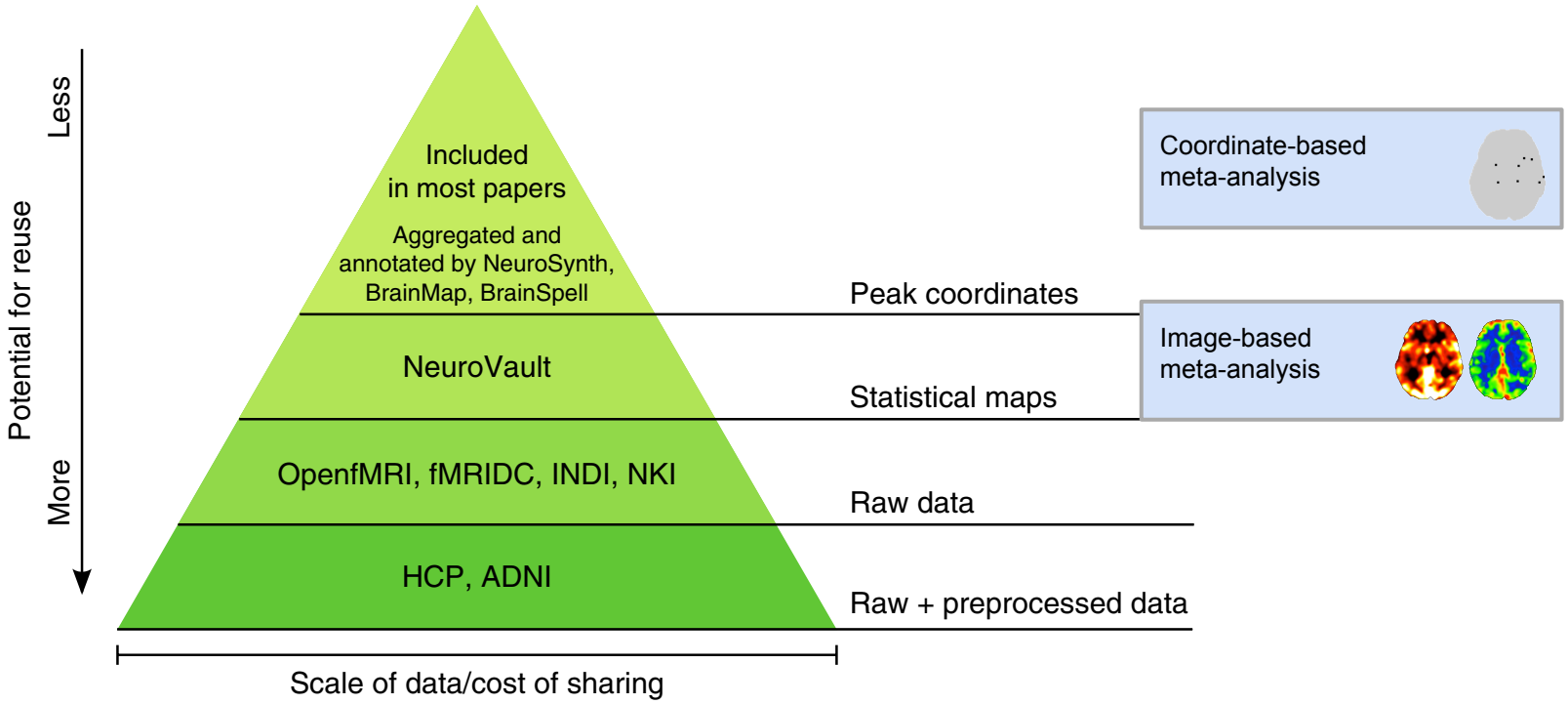


Peaks
(quantitative)

Coordinate- or Image-Based meta-analysis?



Which data to share?



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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

BIRN

2 Task Forces

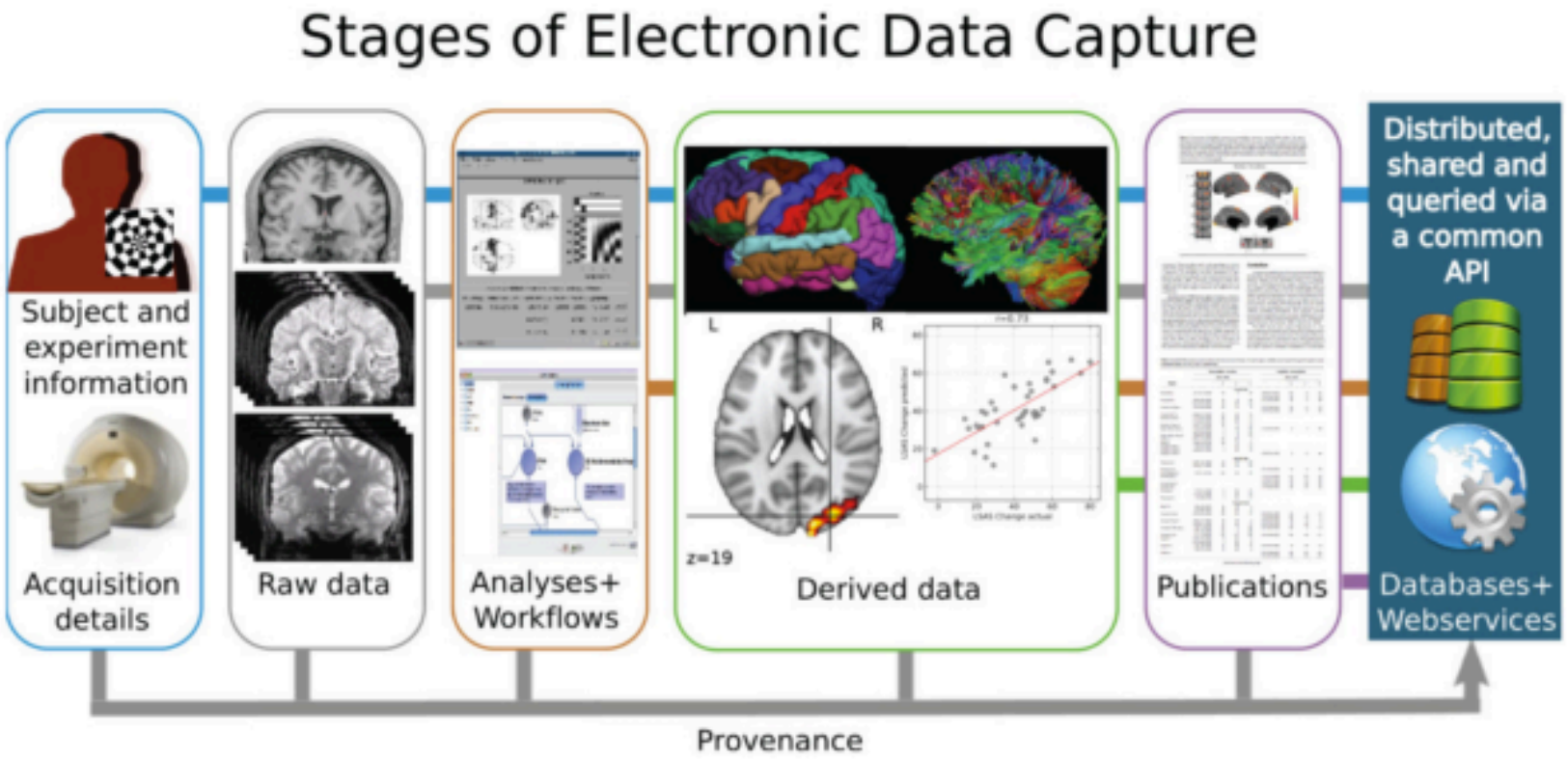
- Neuroimaging (NIDASH)
- Electrophysiology

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

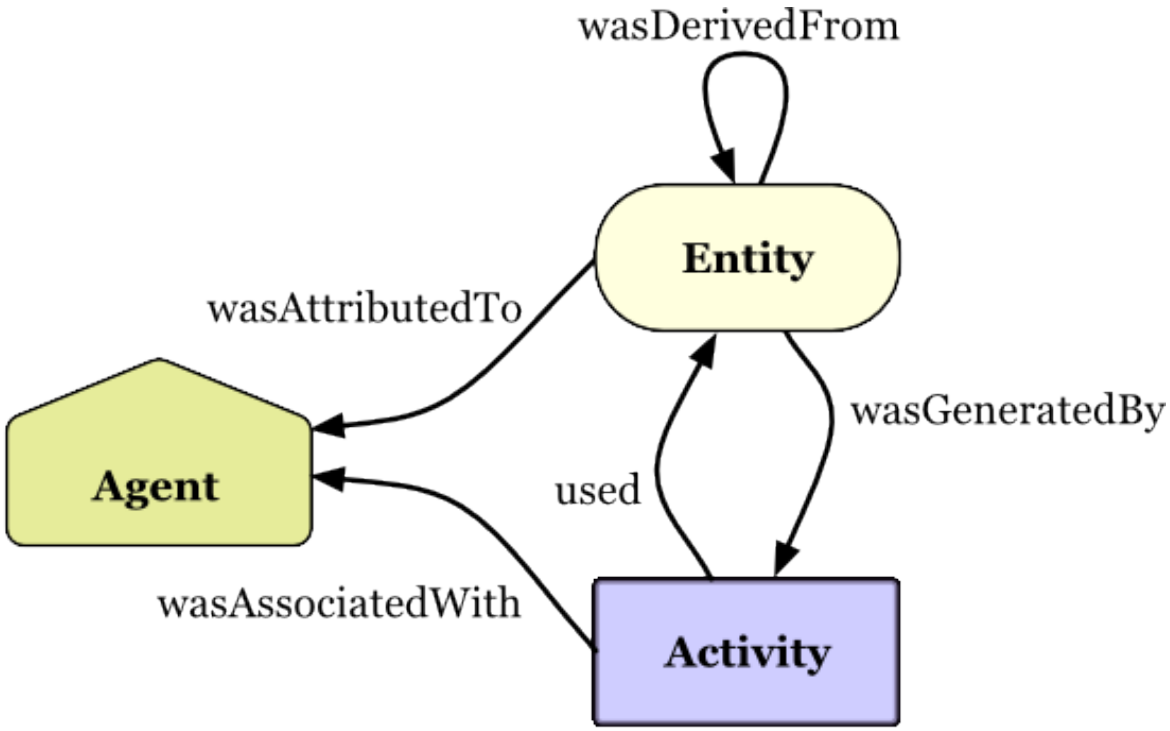


| Electronic Data Capture (EDC) workflow for data sharing in neuroimaging research.

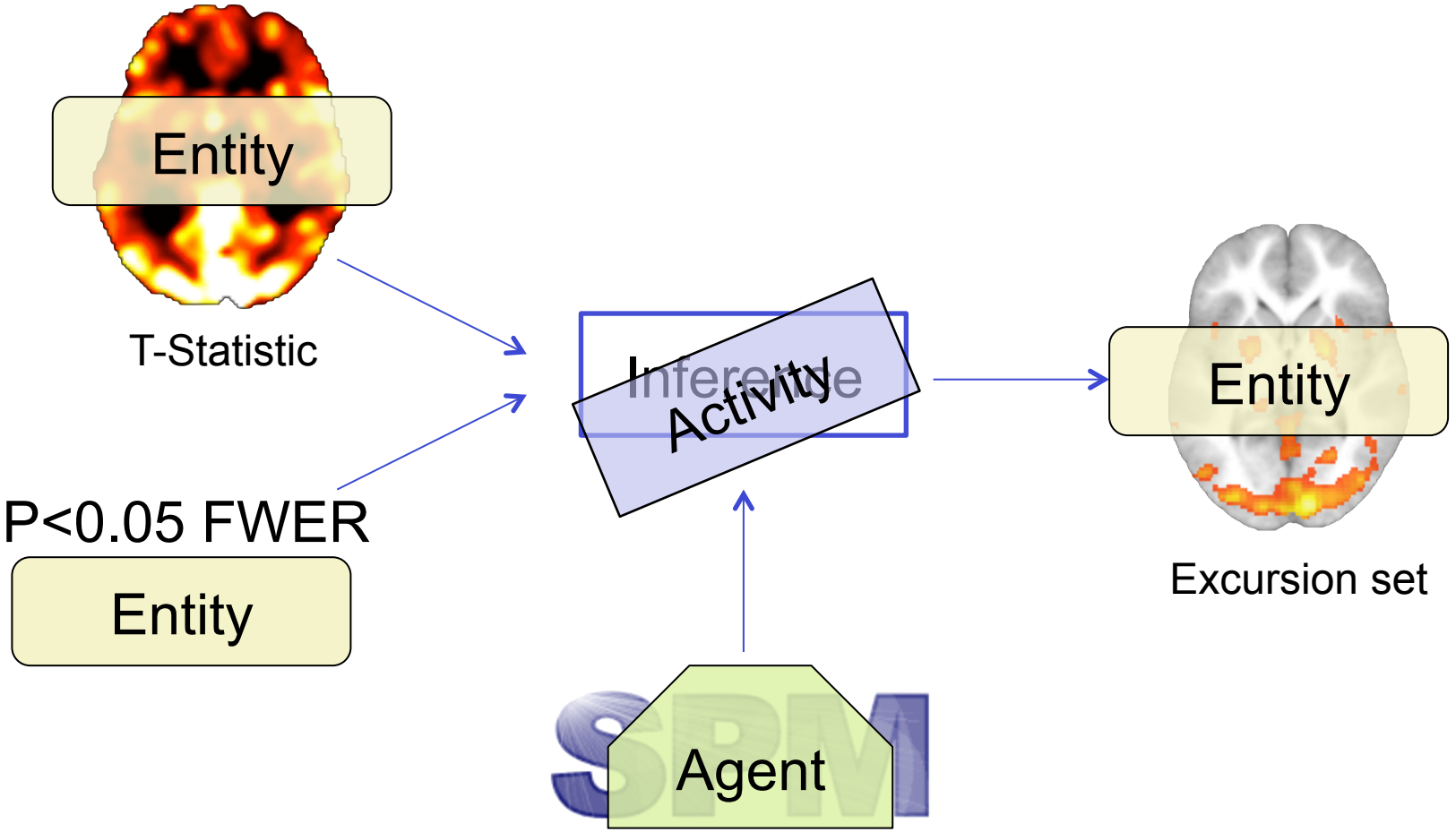
Source: Poline et al, Frontiers in Neuroinformatics (2012).

NIDM: Neuroimaging Data Model

- Based on PROV-DM



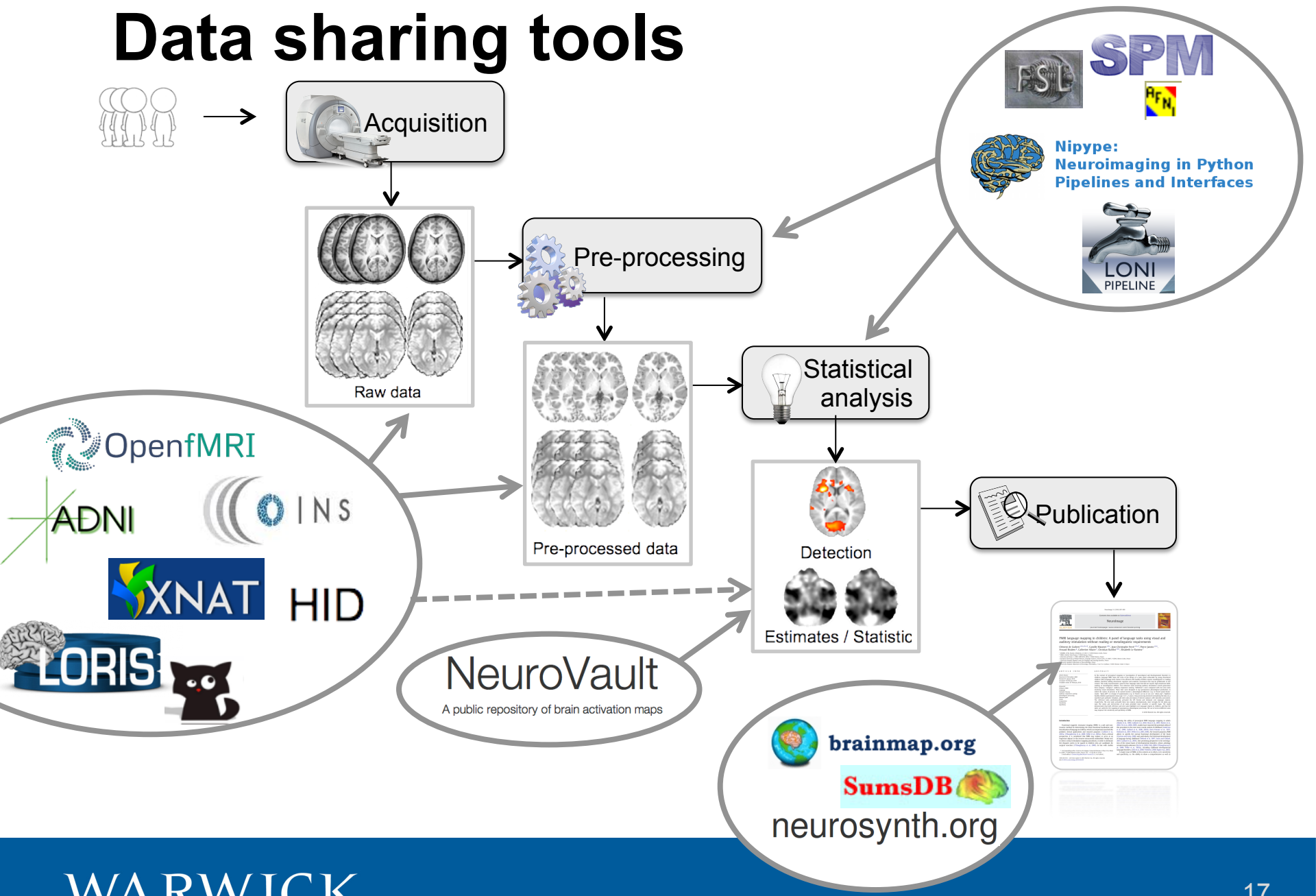
PROV-DM example



CONTEXT

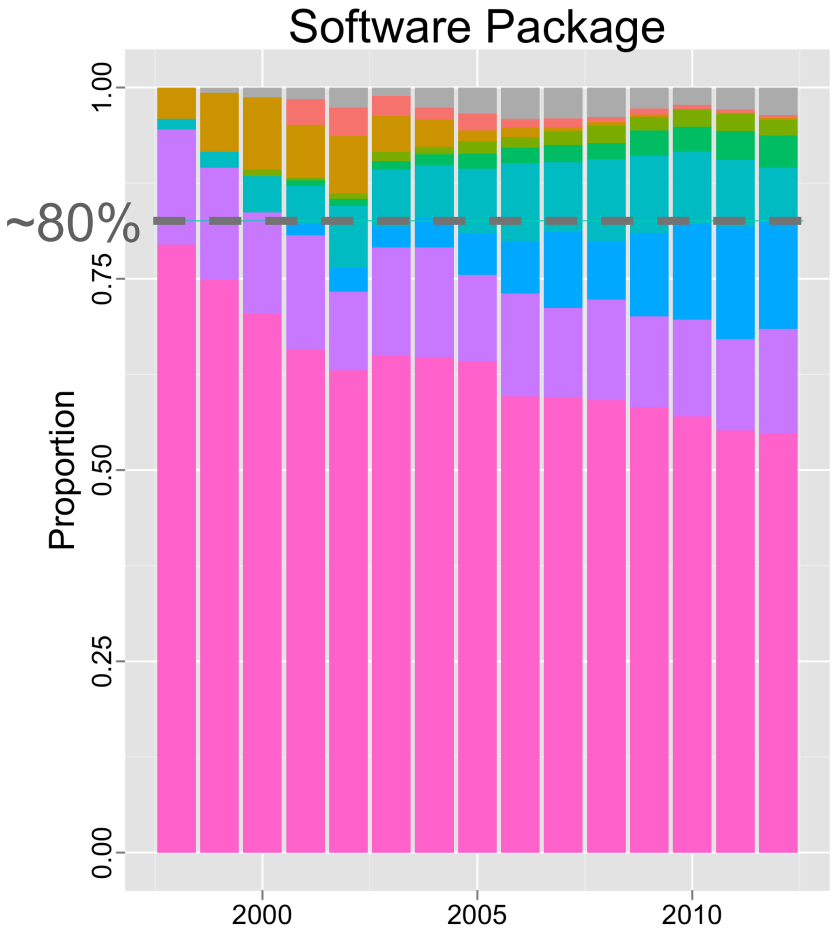
Data sharing environment

Data sharing tools



Three major software packages

other
lipsia
medx
caret
surfer
voyager
FSL
AFNI
SPM

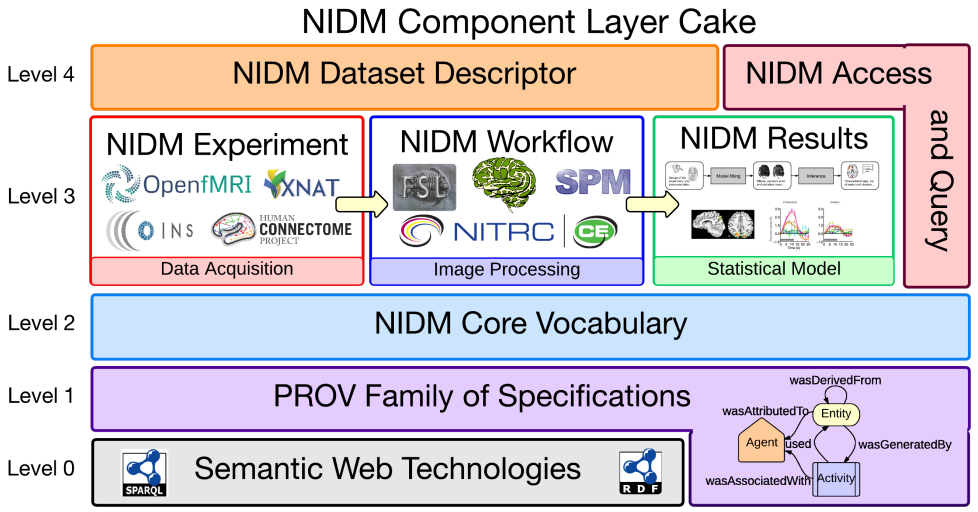


Automatically created with Neurotrends based on over 16 000 journal articles; Source: http://neurotrends.herokuapp.com/static/img/temporal/pkg-prop-year.png

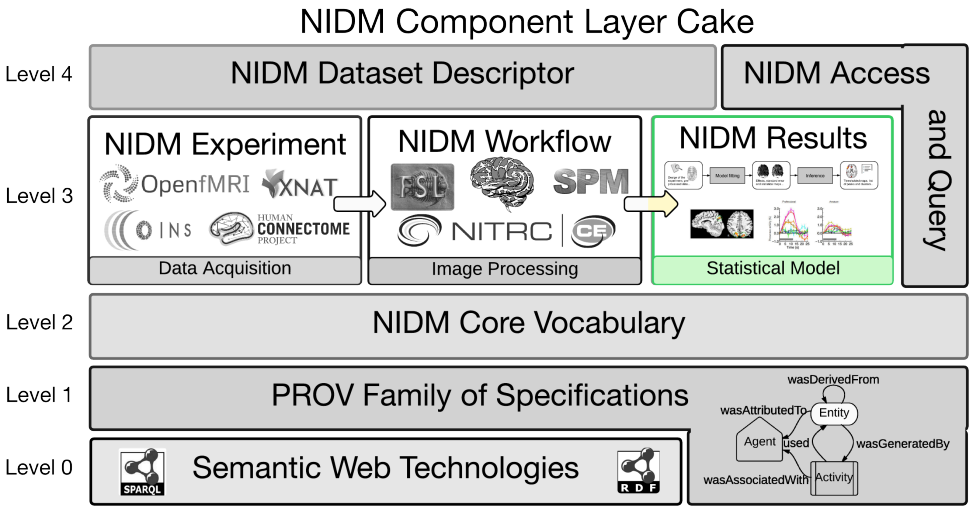
Summary of the problem

- 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



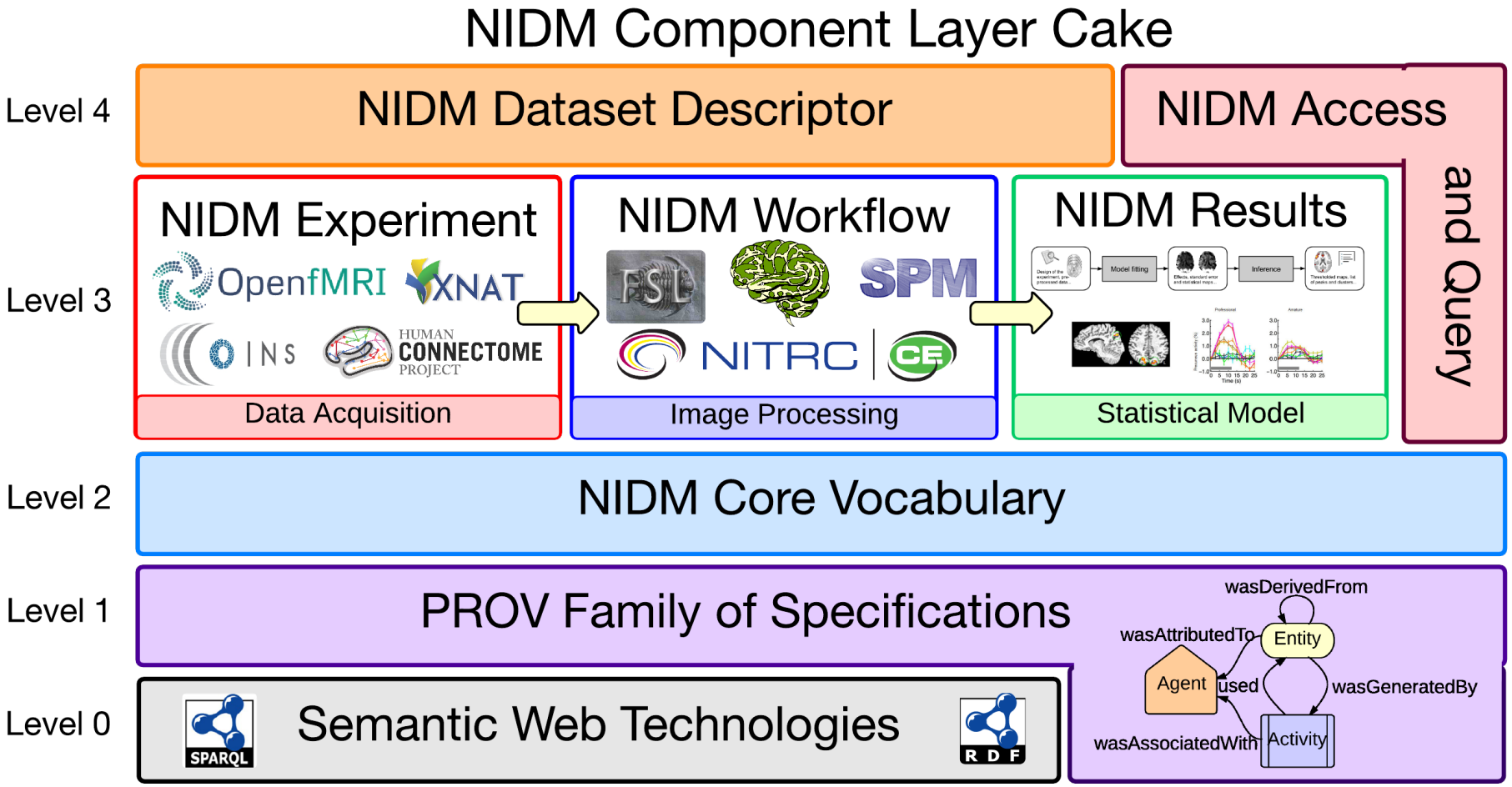
NIDM FOR META-ANALYSIS



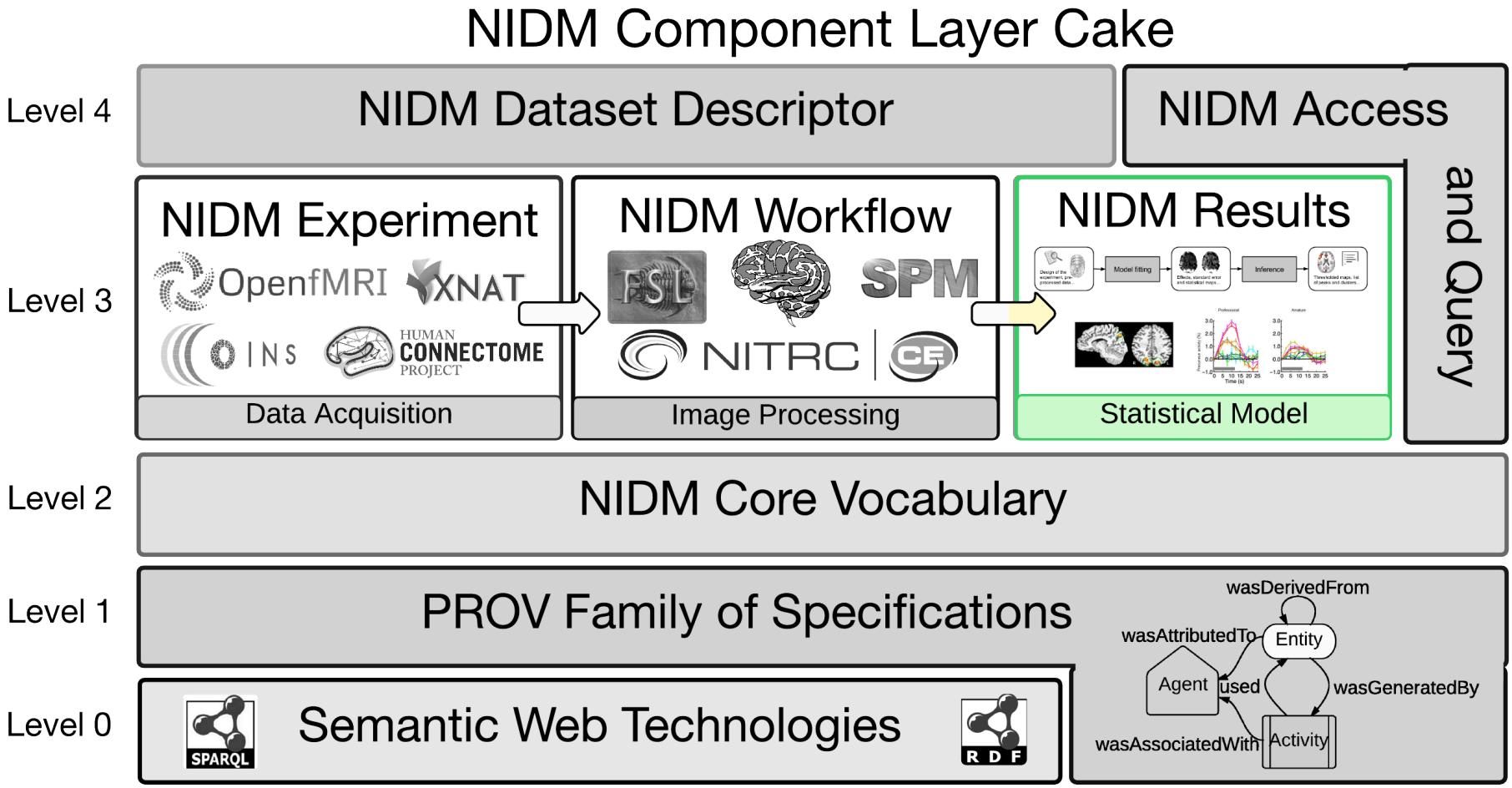
NIDM FOR META-ANALYSIS

NIDM-Results

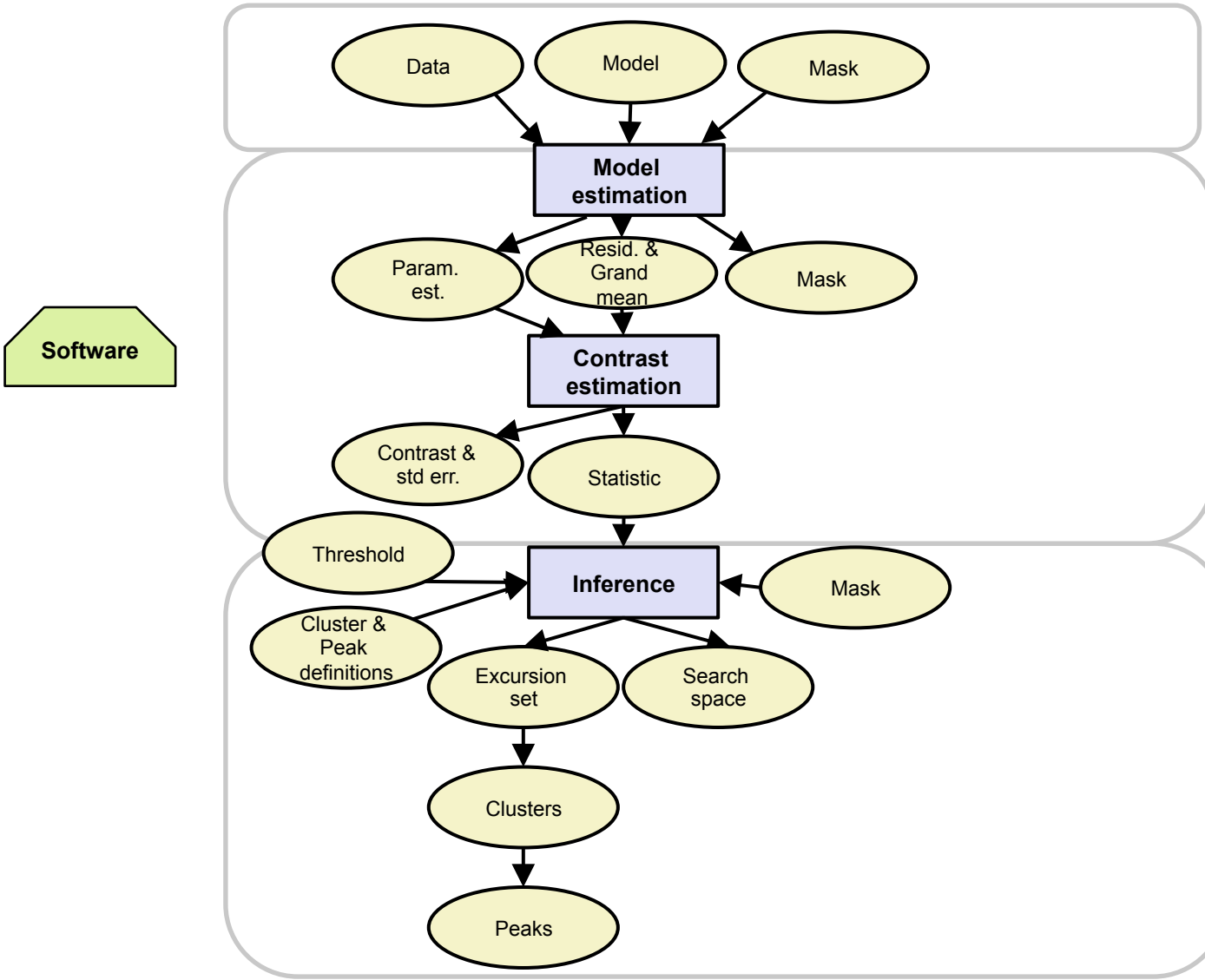
Neuroimaging Data Model

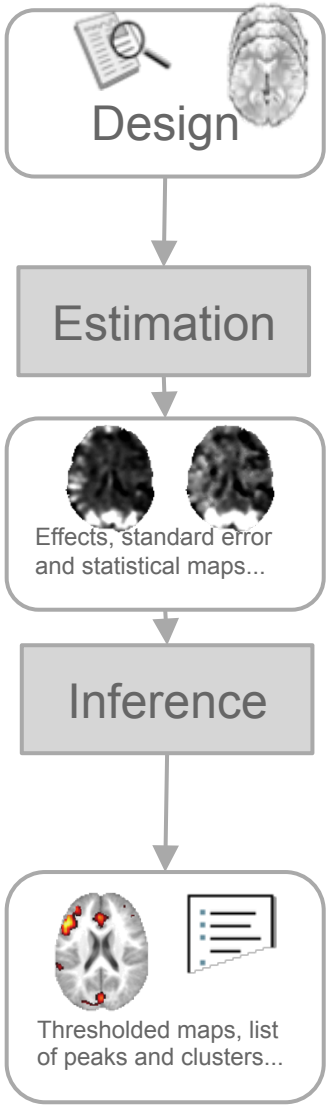


NIDM-Results

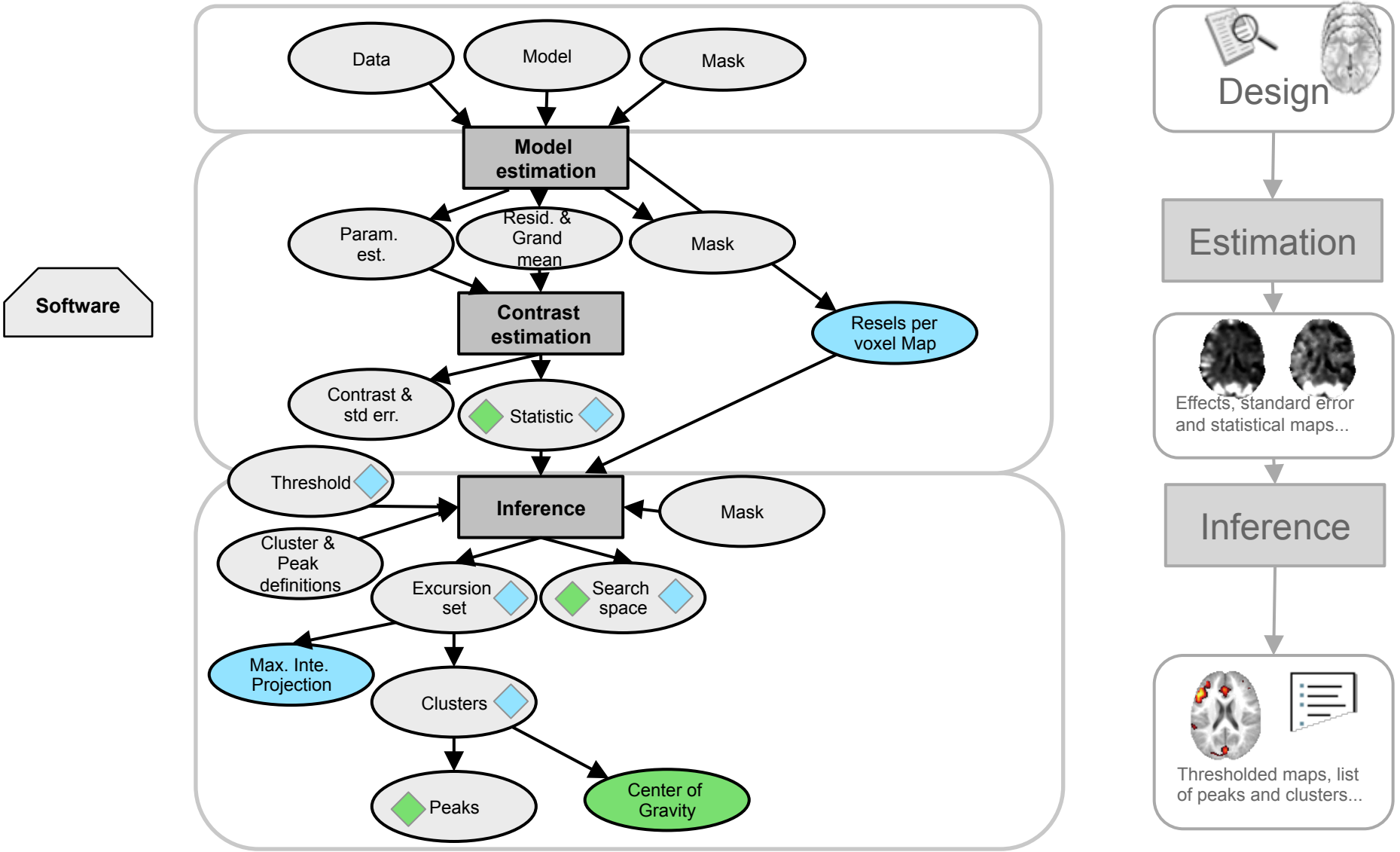


NIDM-Results



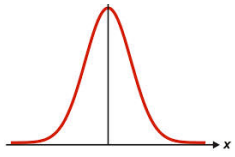


NIDM-Results: software-specific extensions

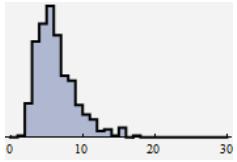


Standardization across software

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

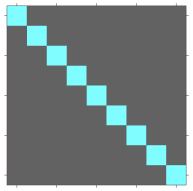


Gaussian

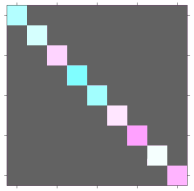


Non-Parametric

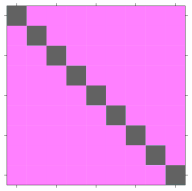
...



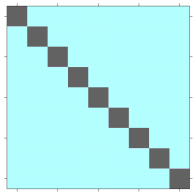
homogeneous



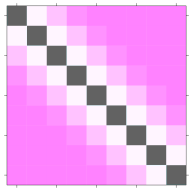
heterogeneous



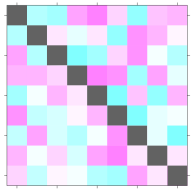
Independent noise



Compound Symmetry



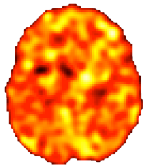
Serially correlated



Arbitrarily correlated

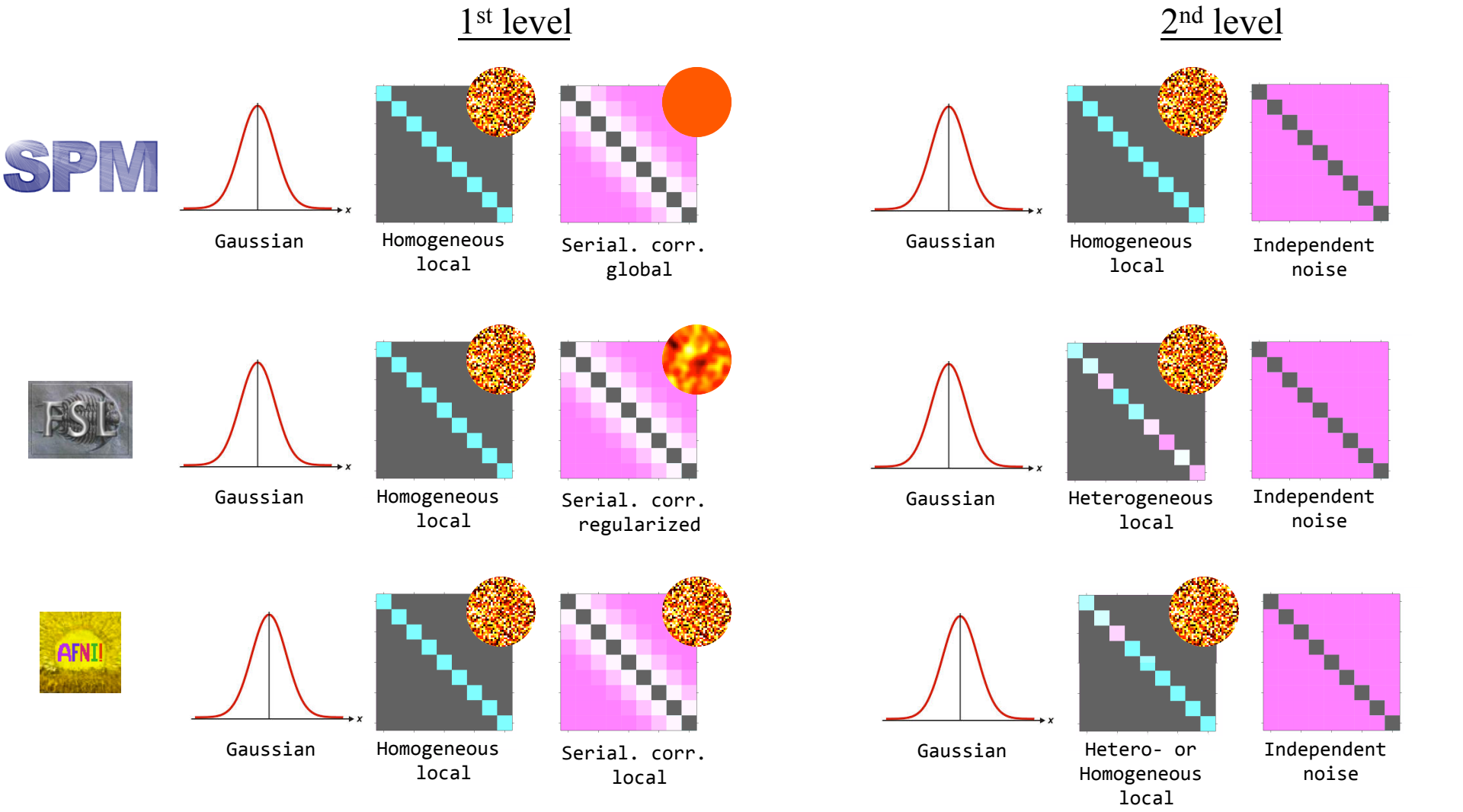
global

local



regularized

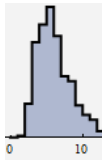
Error models : SPM, FSL and AFNI



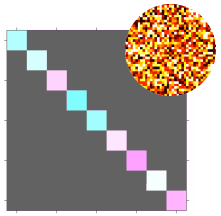
Error models: non-parametric

Randomise

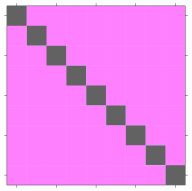
2nd level: Sign-flipping



NonParametric
Symmetric

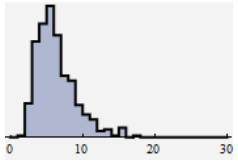


Heterogeneous
local

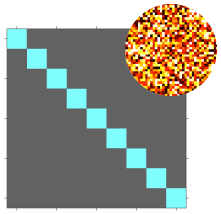


Independent
noise

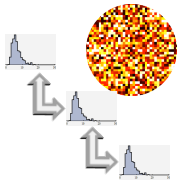
2nd level: Label permutation



NonParametric



Homogeneous
local



Exchangeable
noise local

Terms

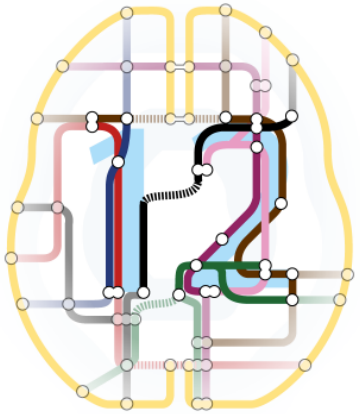
- Terms re-use:
  - Close interaction with STATO (Statistics terms)
  - Dublin Core (file formats)
  - But also: NCIT, OBI…
- Work-in-progress
    - https://github.com/incf-nidash/nidm/
- Aim: include the created terms in Neurolex.

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

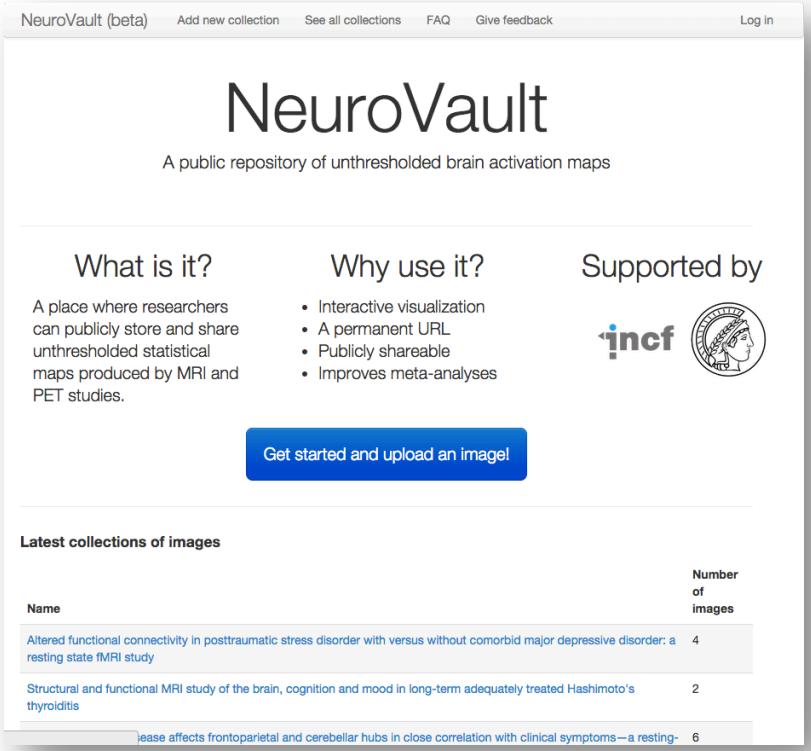
Future directions

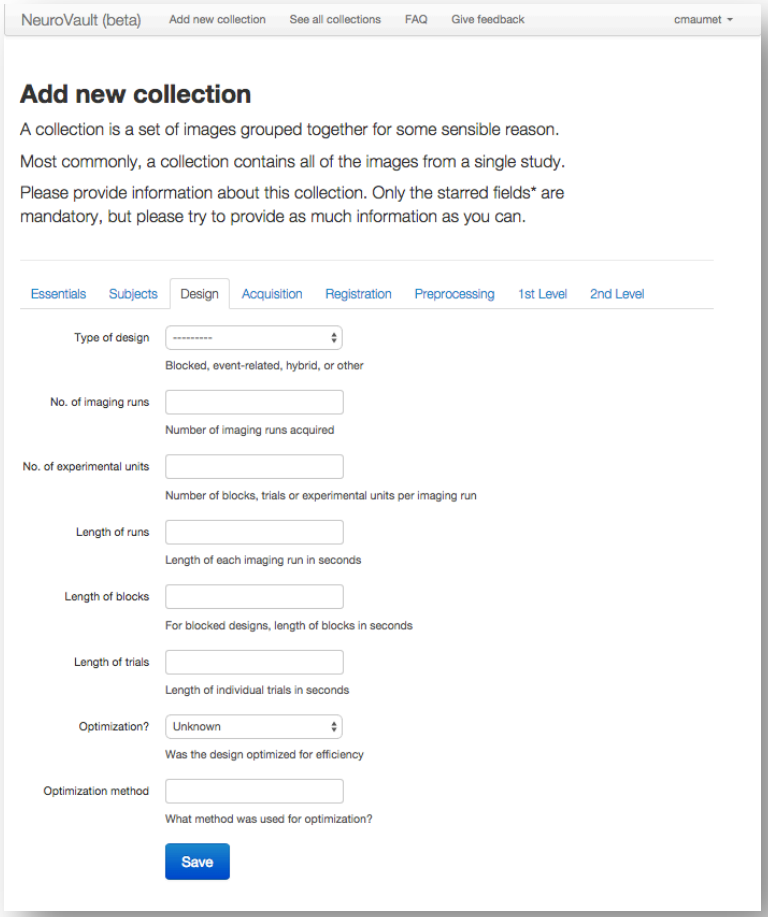
Next steps and future plans

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

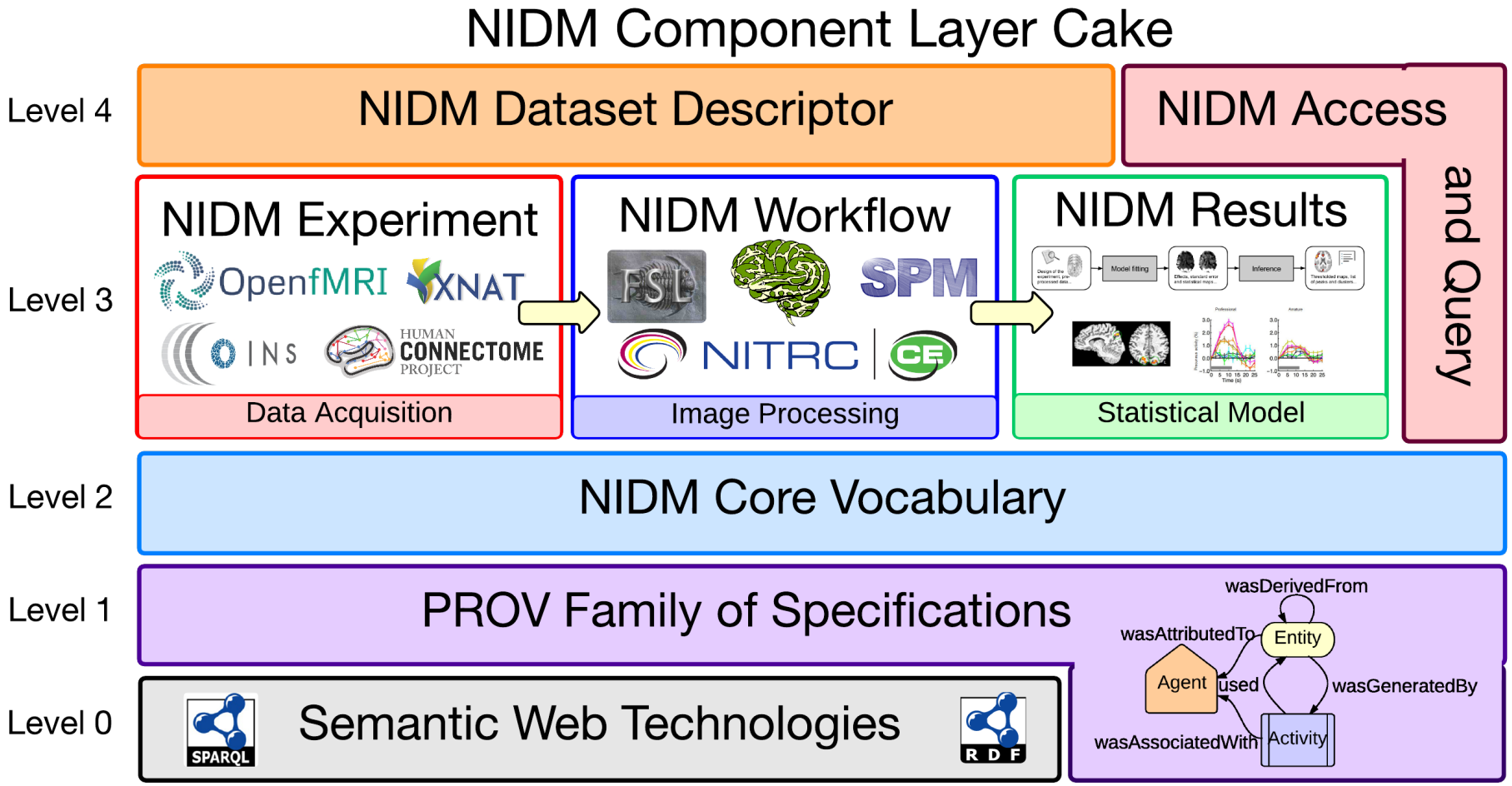
Next steps and future plans

- NIDM import for Neurovault





NIDM effort


NIDM Component Layer Cake
Level 4
NIDM Dataset Descriptor
NIDM Access and Query
Level 3
NIDM Experiment
OpenfMRI
XNAT
INS
HUMAN CONNECTOME PROJECT
Data Acquisition
NIDM Workflow
FSL
SPM
NITRC
CE
Image Processing
NIDM Results
Model fitting
Inference
Statistical Model
Level 2
NIDM Core Vocabulary
Level 1
PROV Family of Specifications
wasDerivedFrom
wasAttributedTo
Entity
Agent
used
wasGeneratedBy
wasAssociatedWith
Activity
Level 0
SPARQL
Semantic Web Technologies
RDF

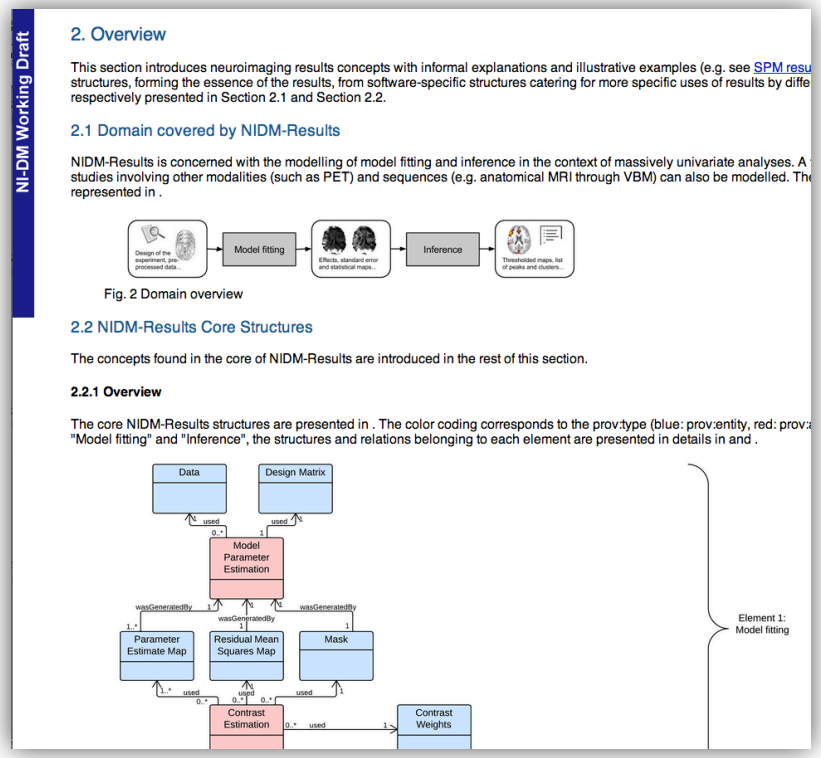
CONCLUSION

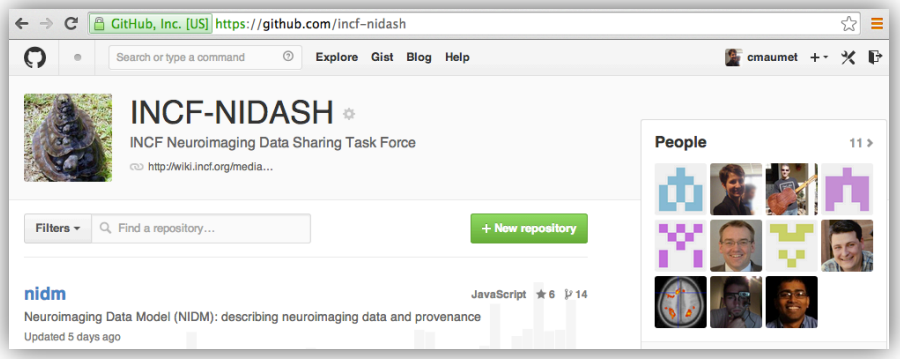
Conclusion

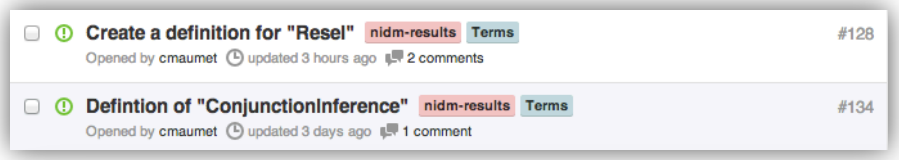
- NIDM-Results: standardized reporting of neuroimaging results
  - Use-case: Meta-analysis
  - Discussions: https://github.com/incf-nidash/nidm
  - Specification: http://nidm.nidash.org
  - Implementation in SPM12, FSL & (AFNI)
- Next steps
  - Refine the terms, AFNI and SnPM/Randomise models
  - Build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

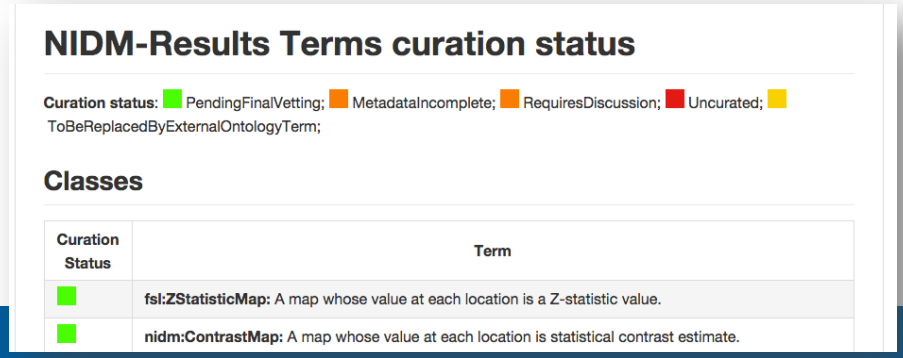
Resources

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









Acknowledgements

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

NIDM working group

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INCF NIDASH - Other members

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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