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Standardized reporting of neuroimaging results with NIDM

Camille Maumet

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Standardized reporting of neuroimaging results with NIDM

Jan. 26th 2015

University of California at Berkeley

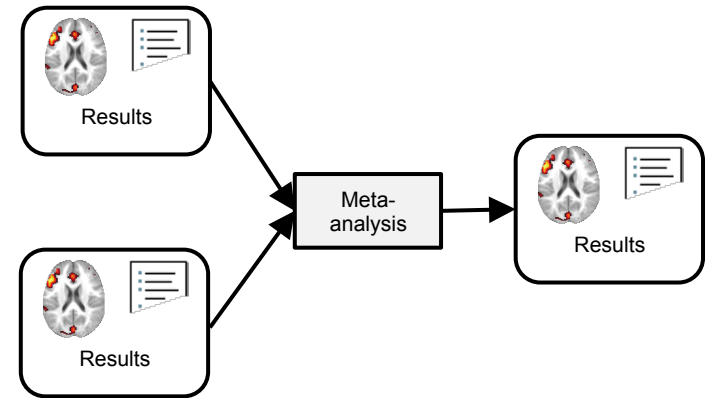
Camille Maumet

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

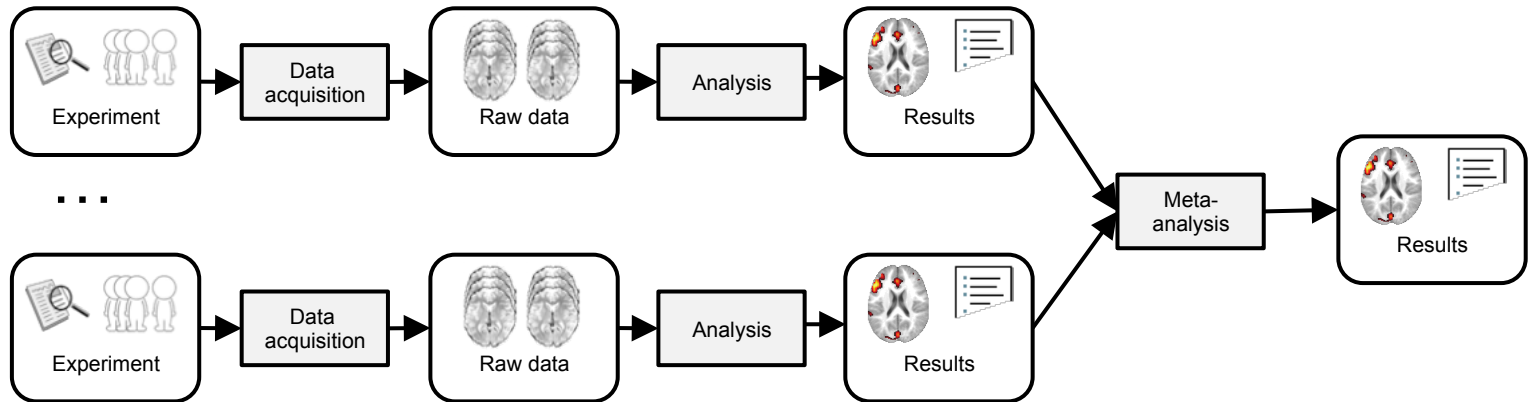
CONTEXT



CONTEXT

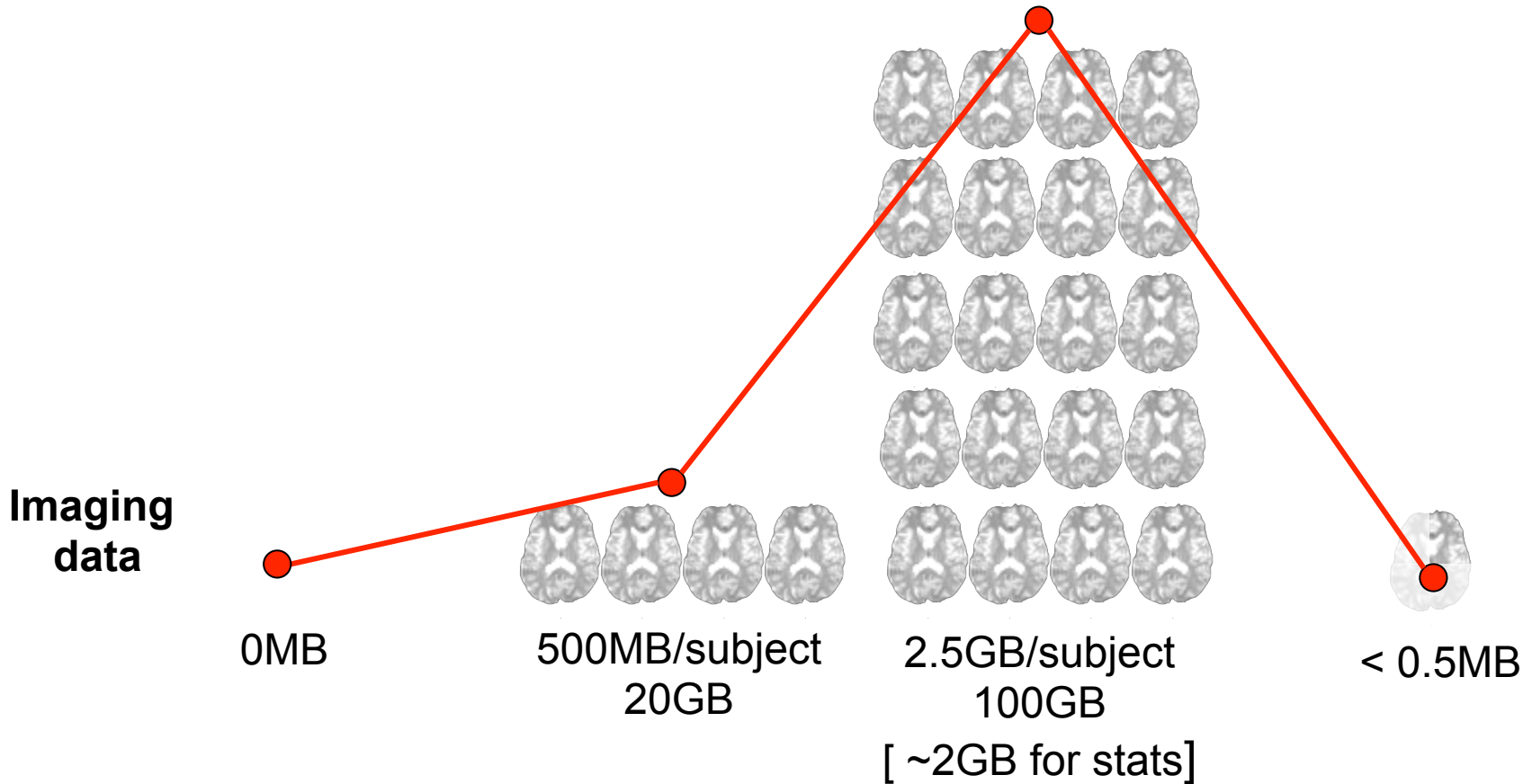
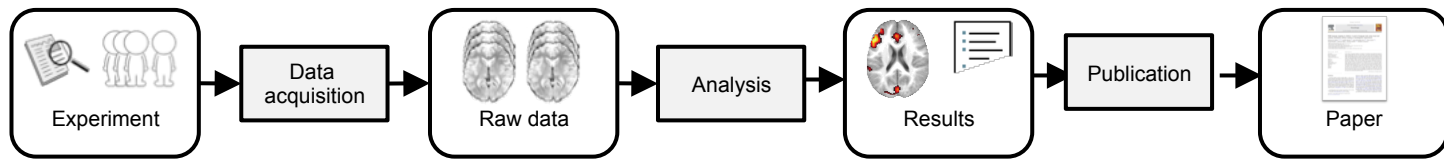
Meta-analysis in neuroimaging

Why meta-analyses?

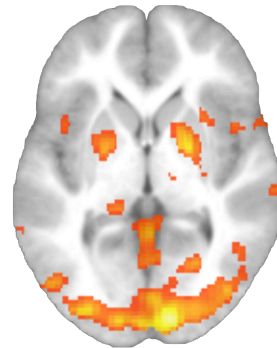
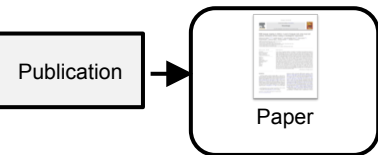


- Increase statistical power
- Combine information across studies

Data analysis in neuroimaging



Data analysis in neuroimaging



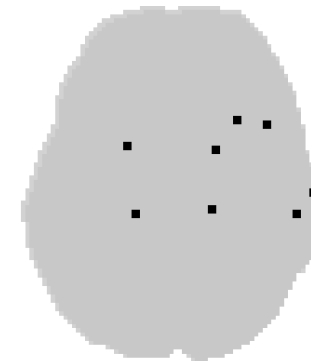
Detection images
(qualitative)

Table 2

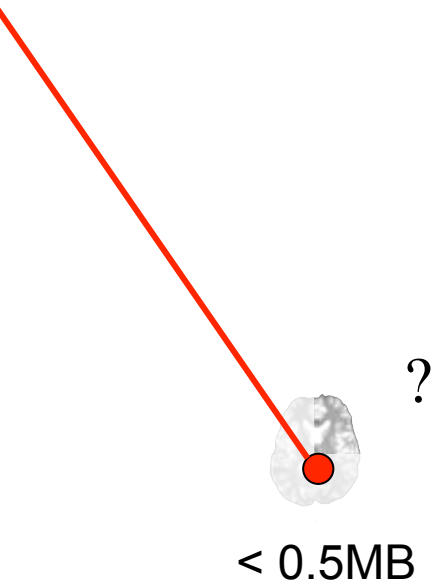
Task comparisons (>) and conjunctions (C). Peak locations, cluster extent-Z-score ($p < 0.001$ unc.; $k = 10$).

| | 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⁾ | -- | 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 |

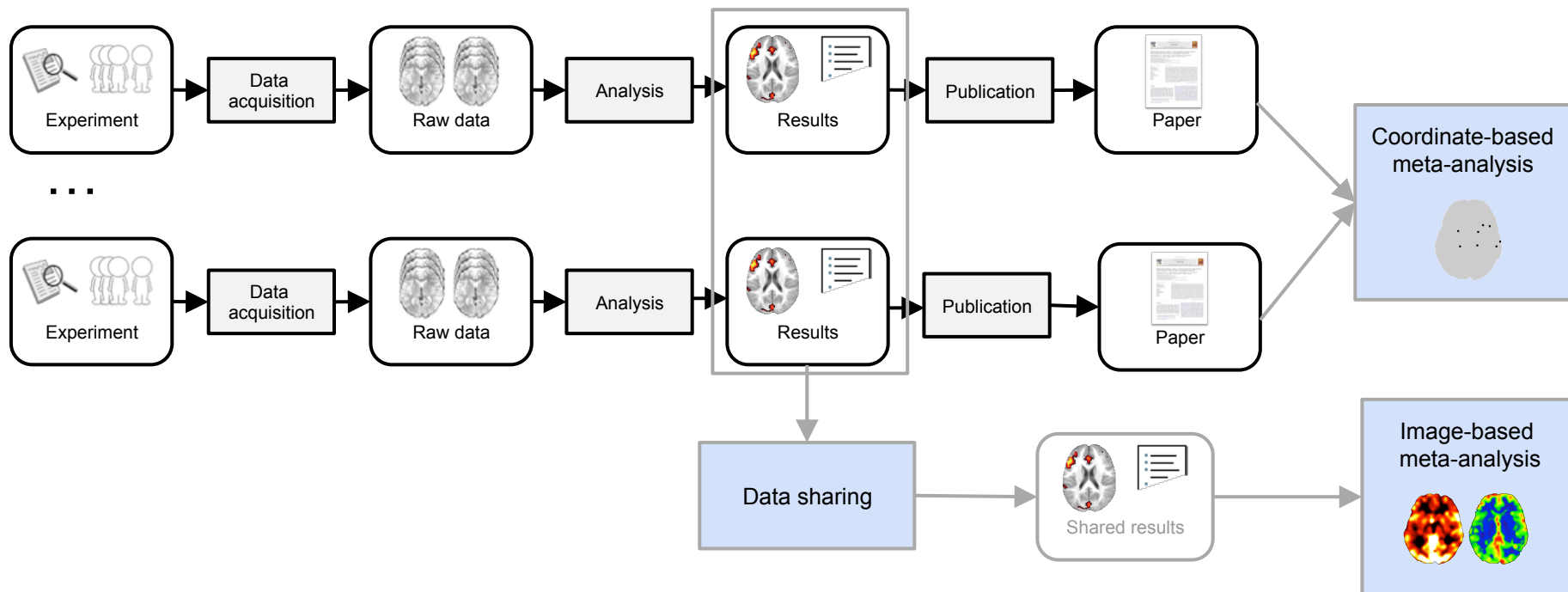
Table of local maxima
(quantitative)



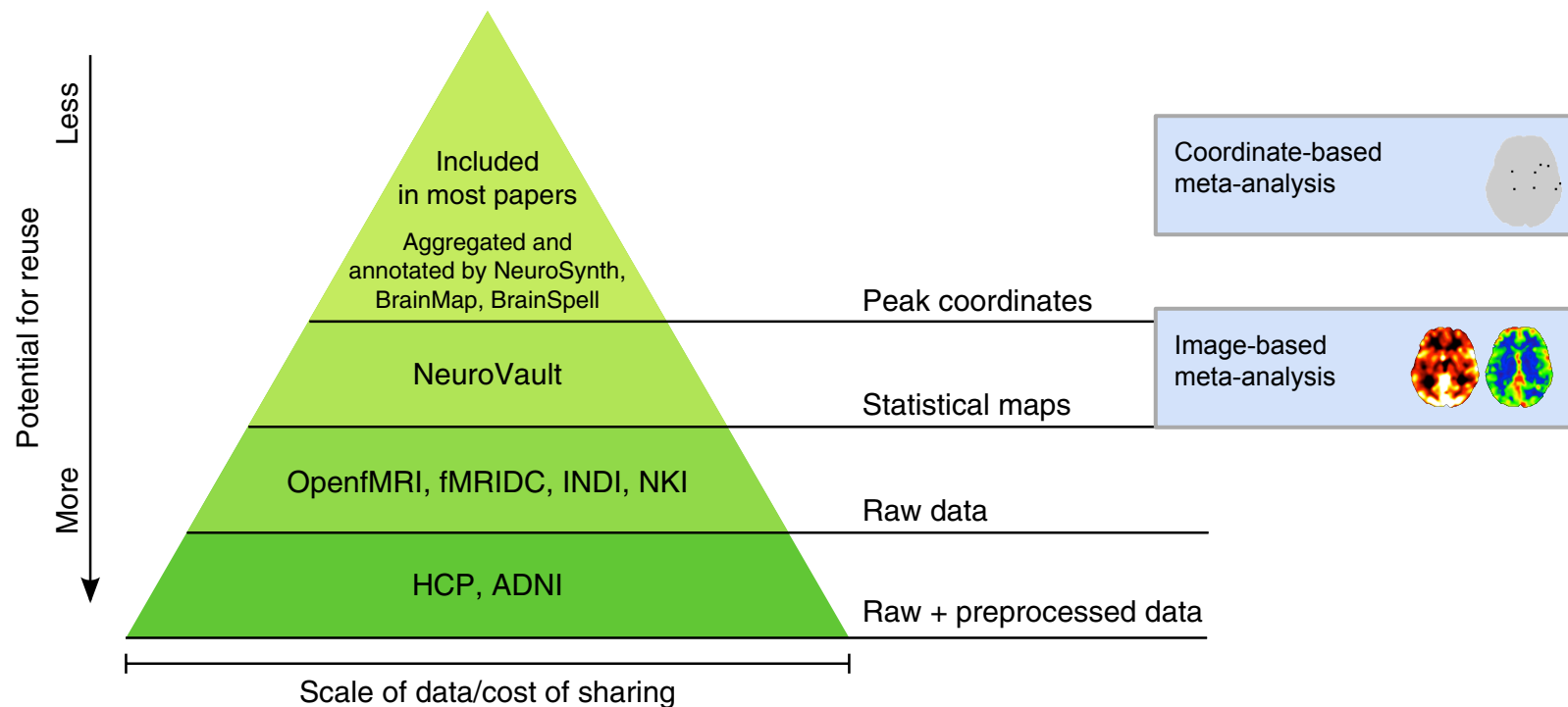
Peaks
(quantitative)



Coordinate- or Image-Based meta-analysis?



Which data to share?

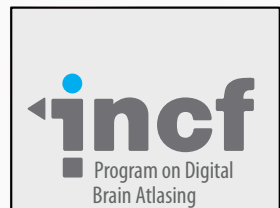


Reprinted by permission from Macmillan Publishers Ltd: Nature neuroscience (Poldrack, R. a, & Gorgolewski, K. J. (2014). Making big data open : data sharing in neuroimaging. Nature Neuroscience, 17(11). doi:10.1038/nn.3818), copyright (2014)

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

BIRN

2 Task Forces

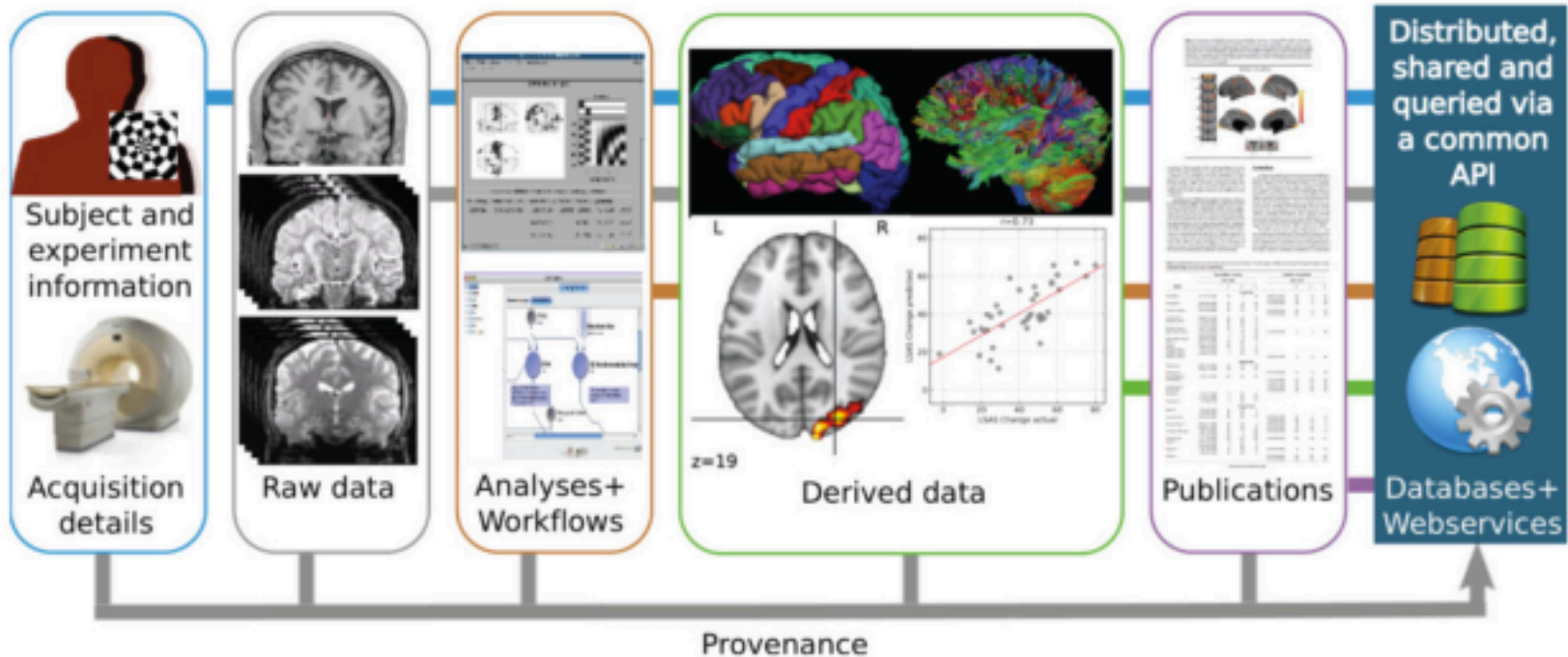
- Neuroimaging (NIDASH)
- Electrophysiology

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

Stages of Electronic Data Capture

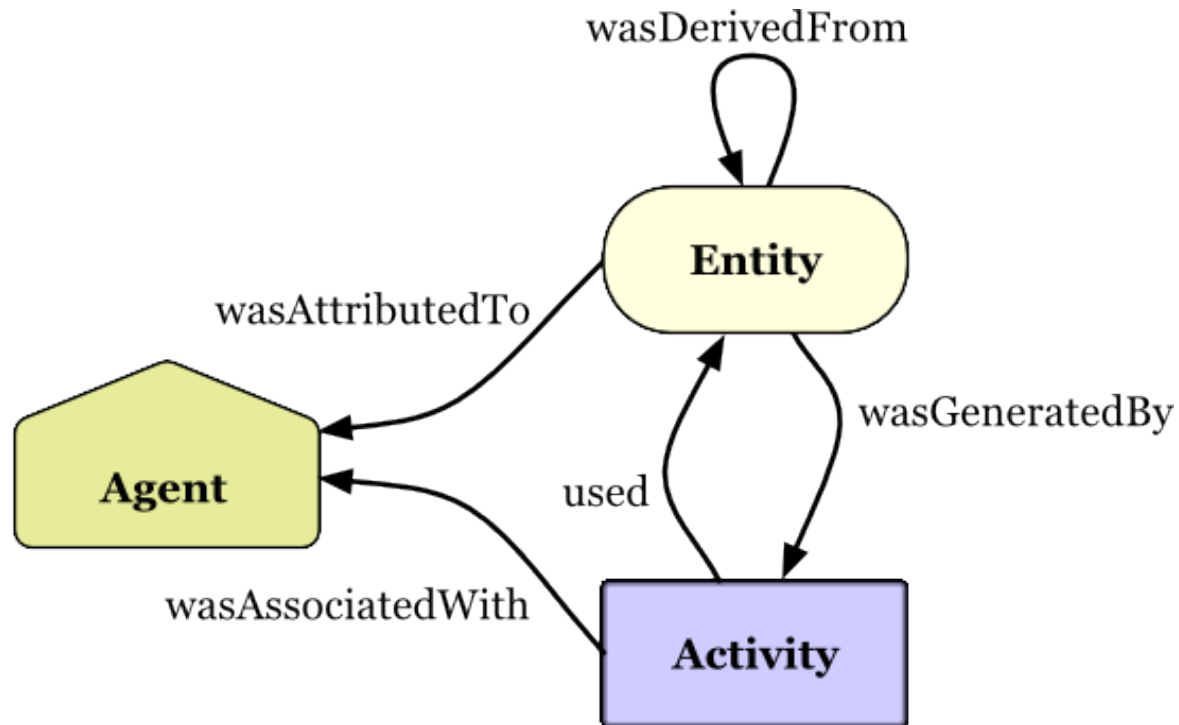


| Electronic Data Capture (EDC) workflow for data sharing in neuroimaging research.

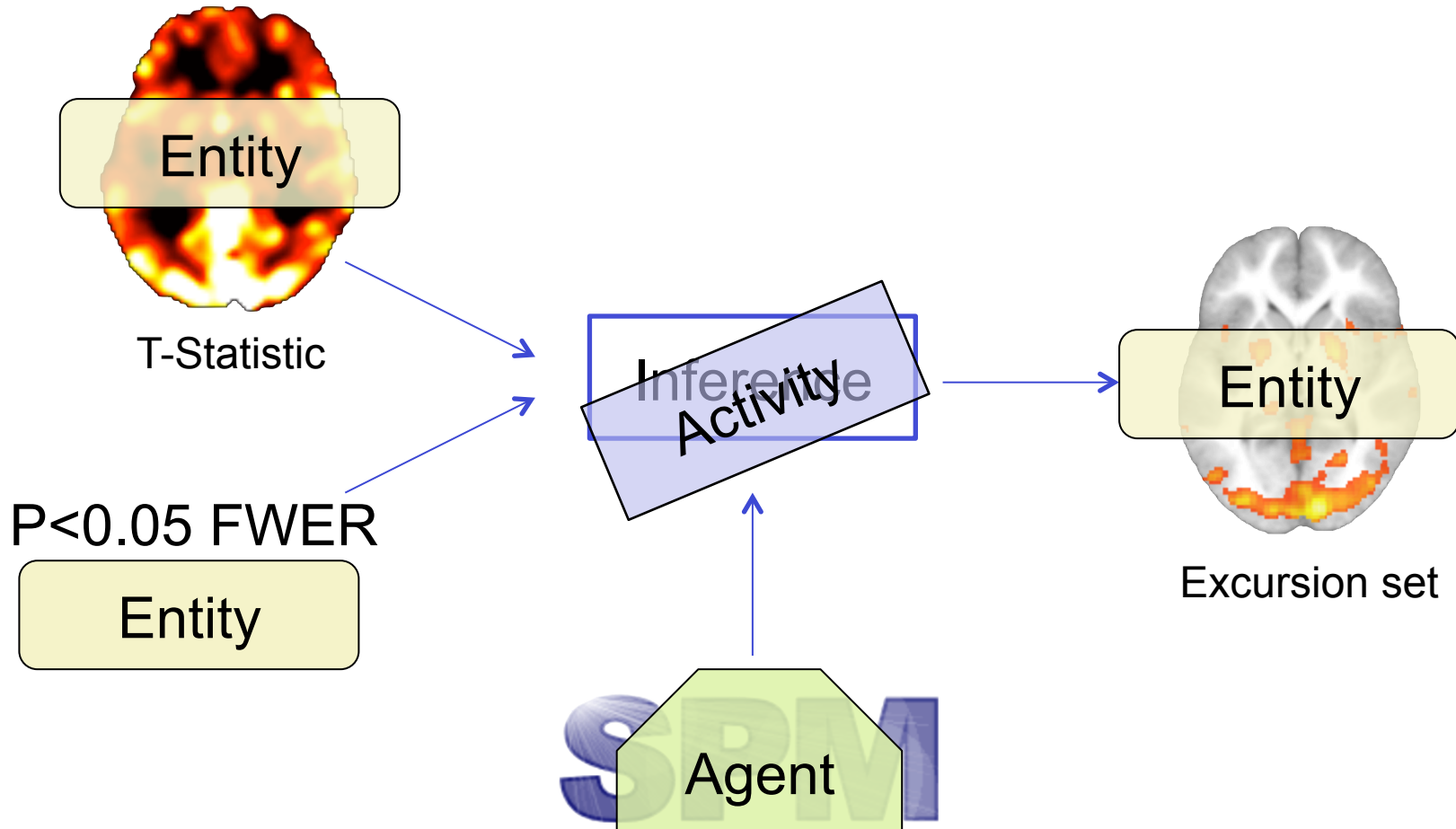
Source: Poline et al, Frontiers in Neuroinformatics (2012).

NIDM: Neuroimaging Data Model

- Based on PROV-DM



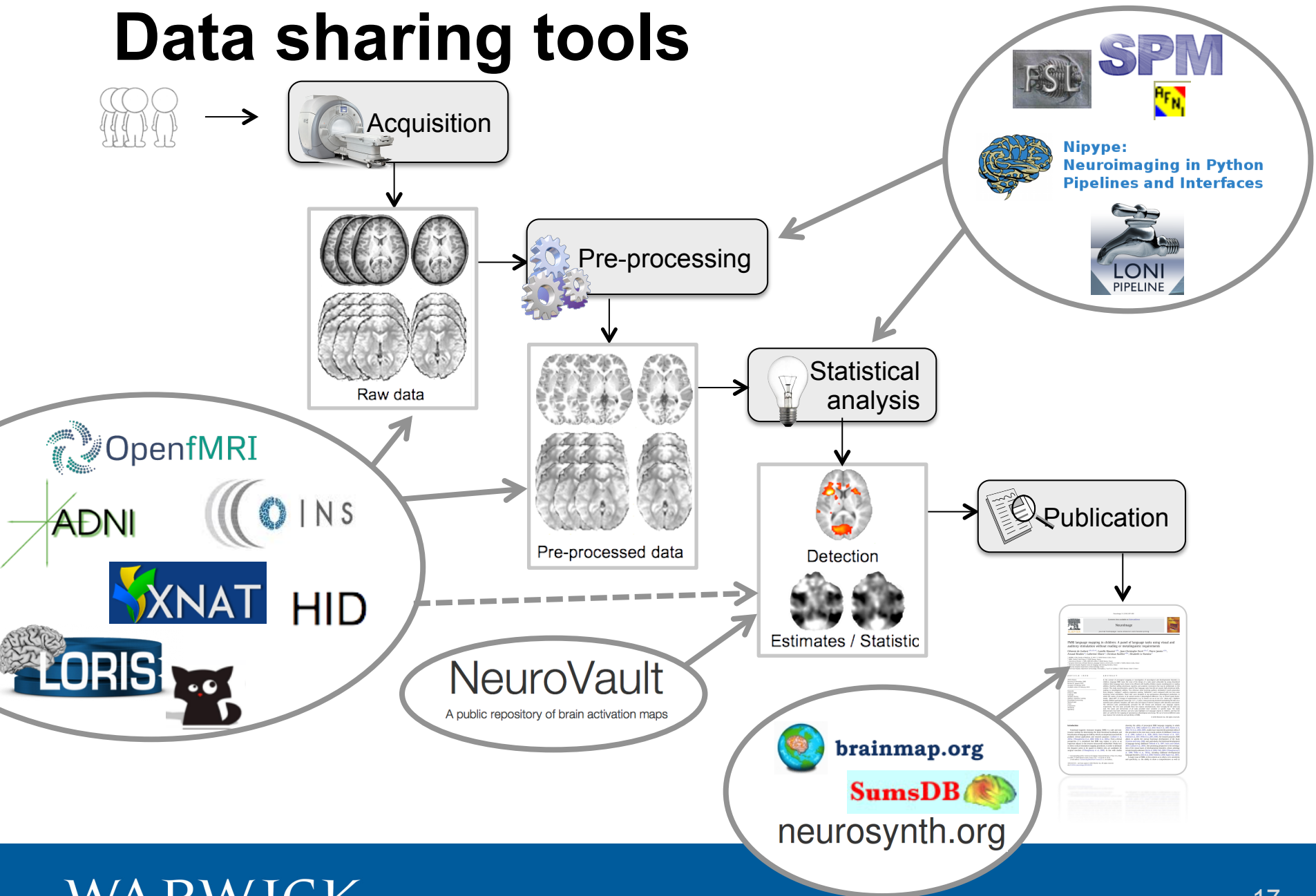
PROV-DM example



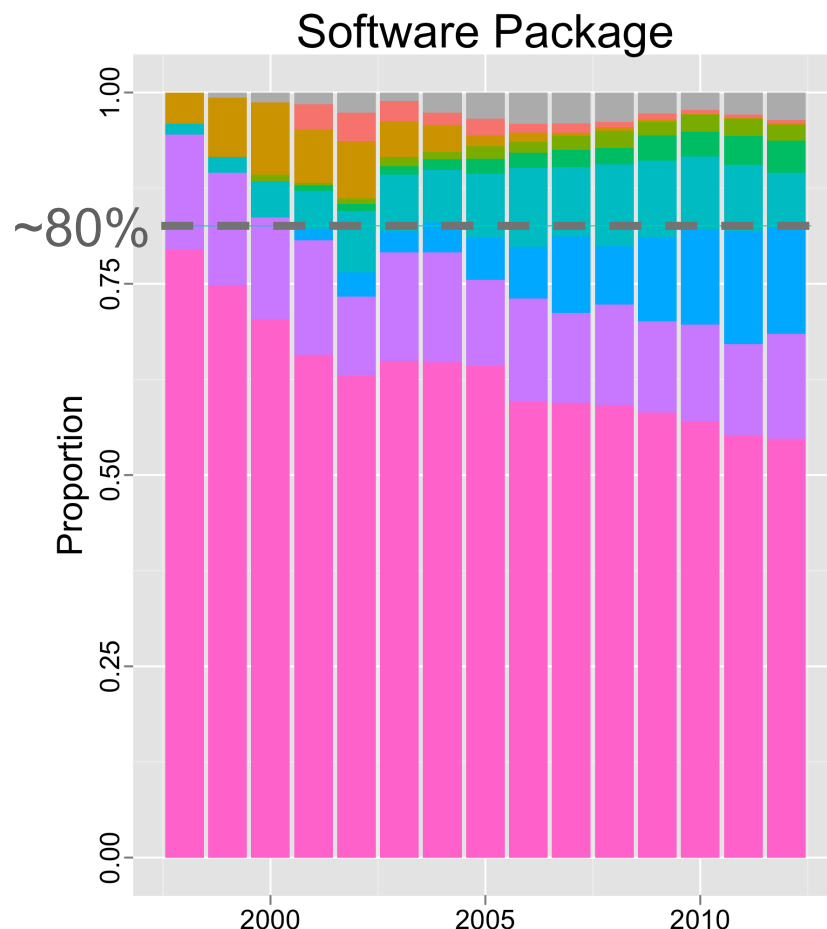
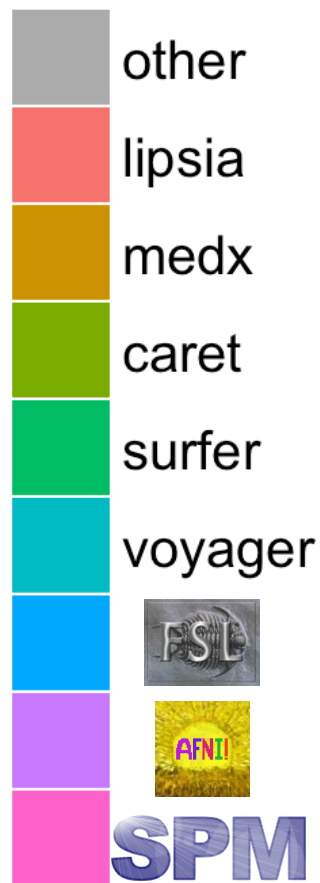
CONTEXT

Data sharing environment

Data sharing tools



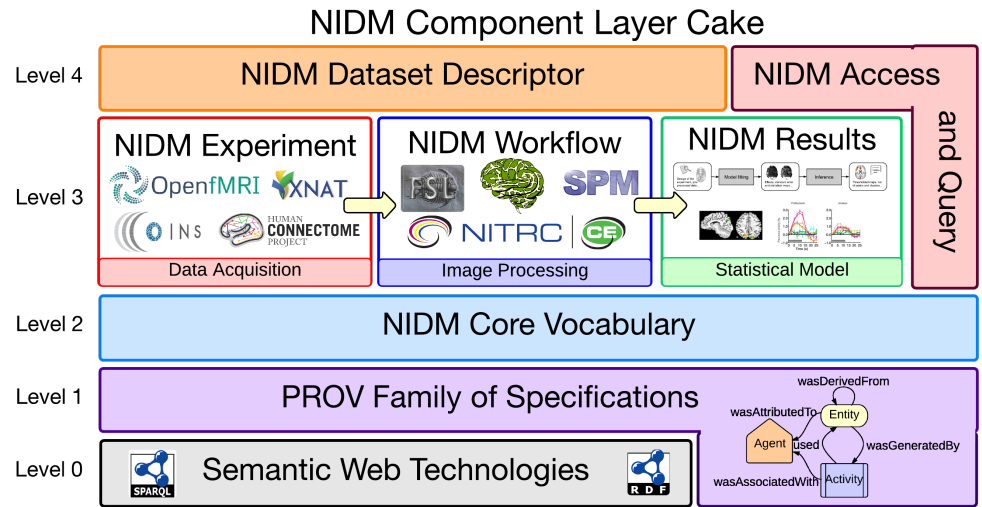
Three major software packages



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

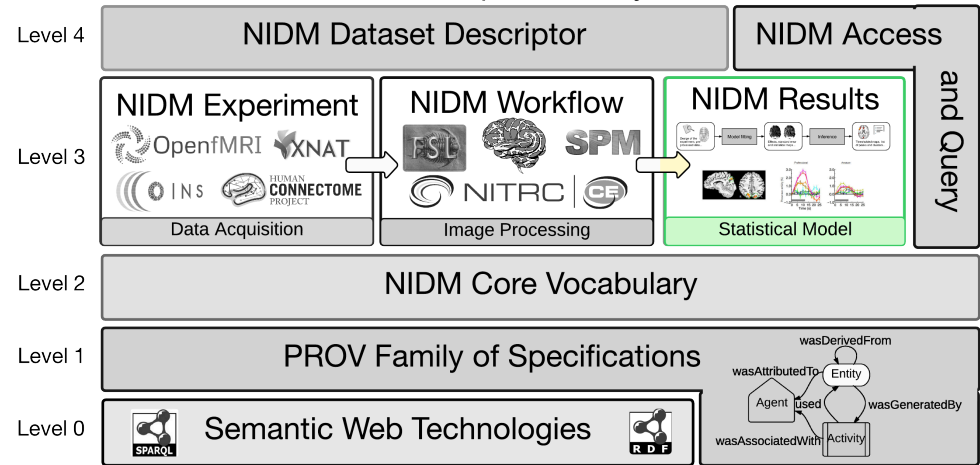
Summary of the problem

- 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 Component Layer Cake

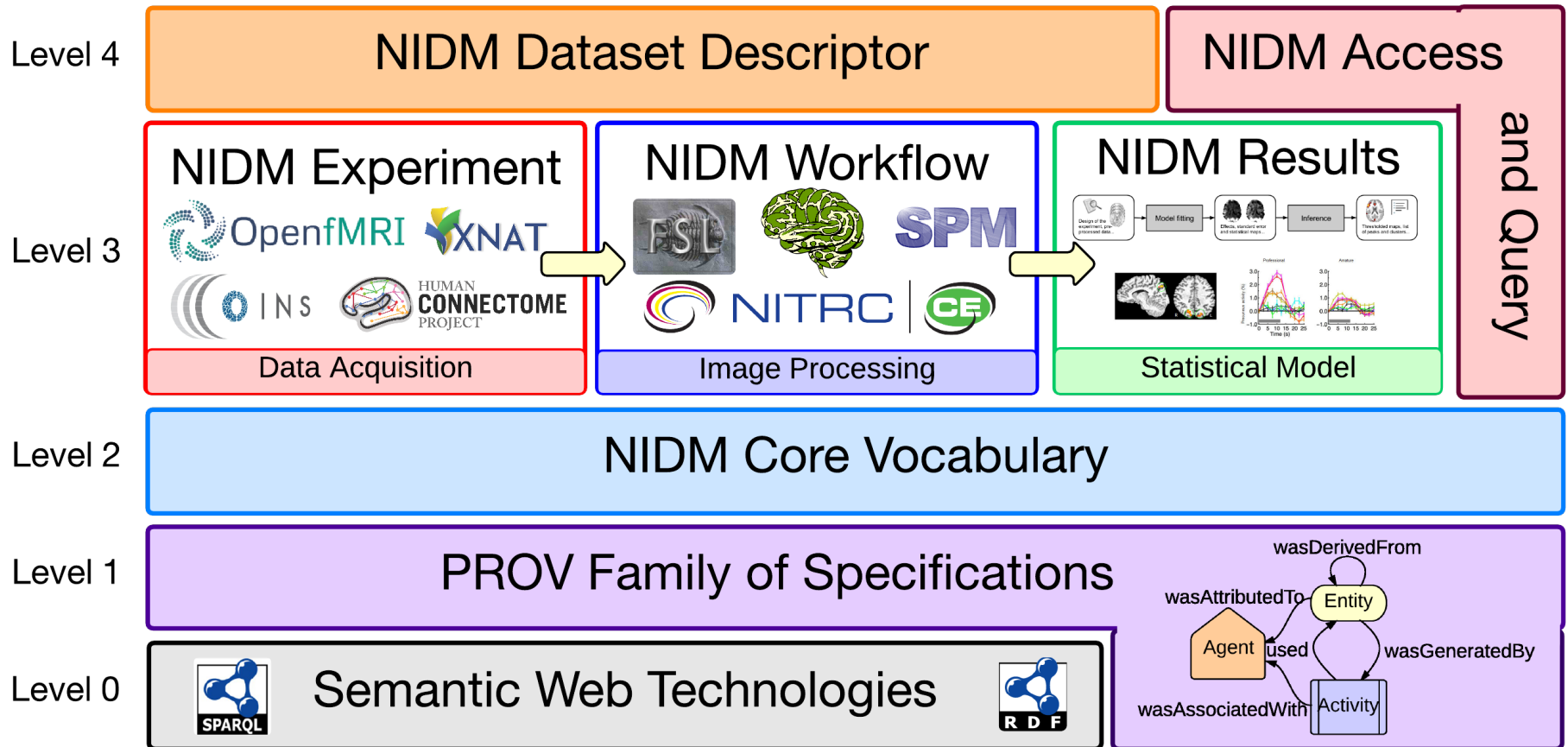


NIDM FOR META-ANALYSIS

NIDM-Results

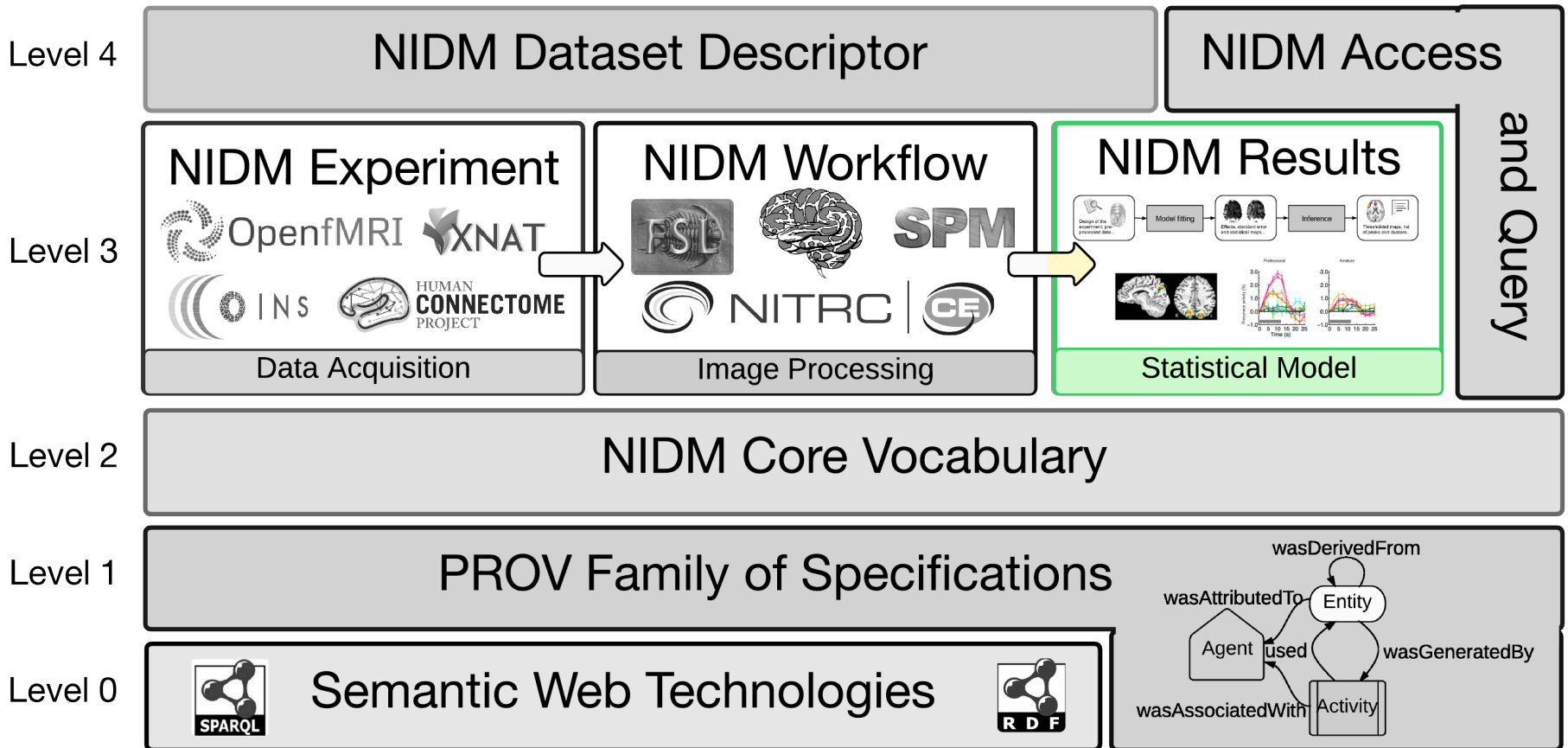
Neuroimaging Data Model

NIDM Component Layer Cake

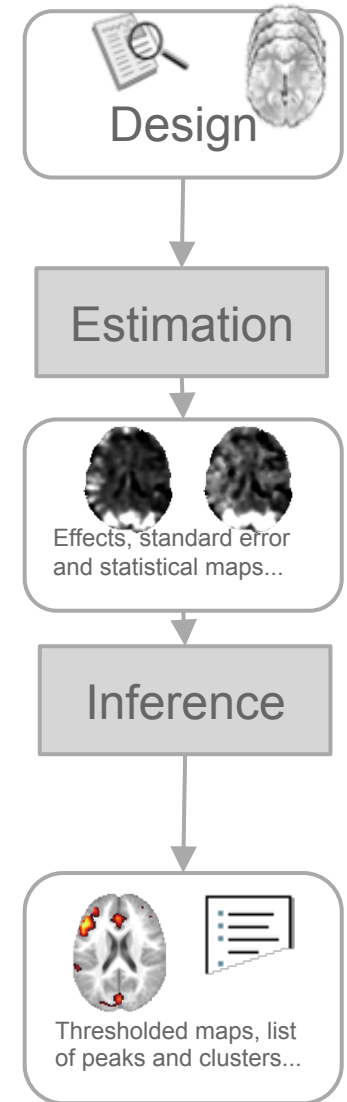
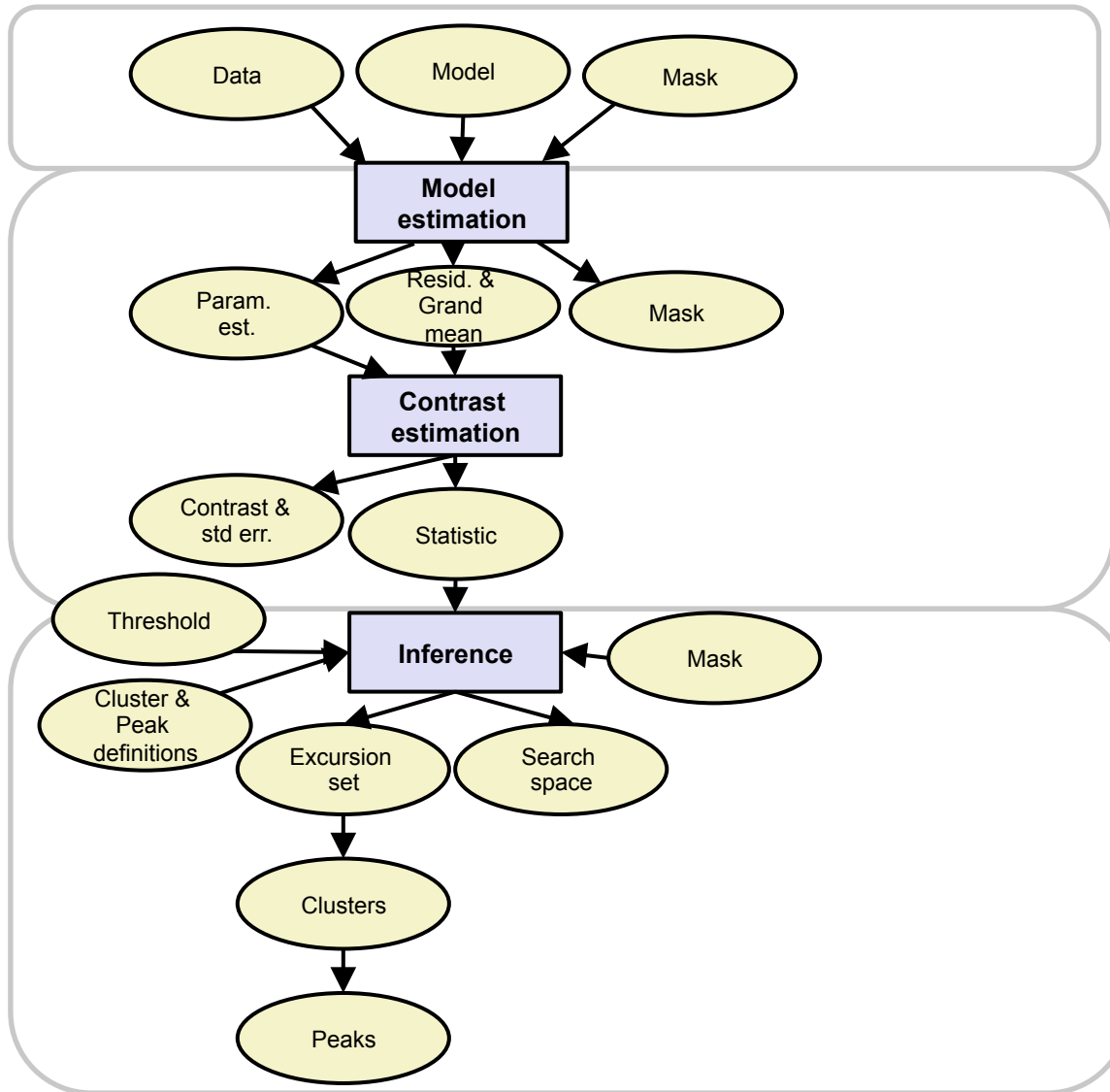


NIDM-Results

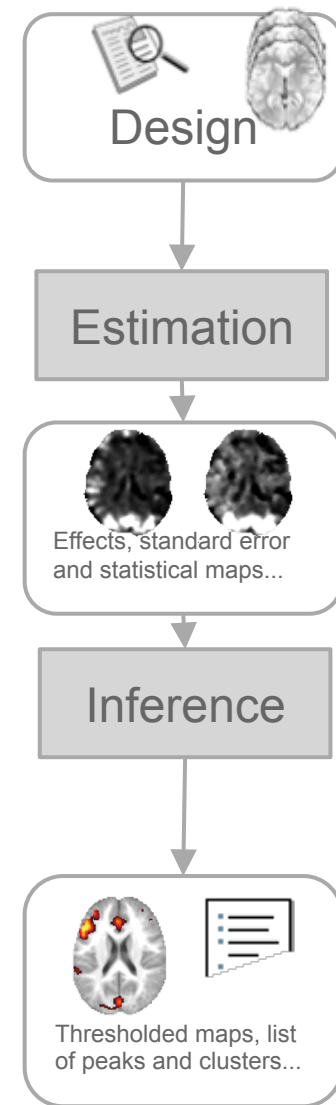
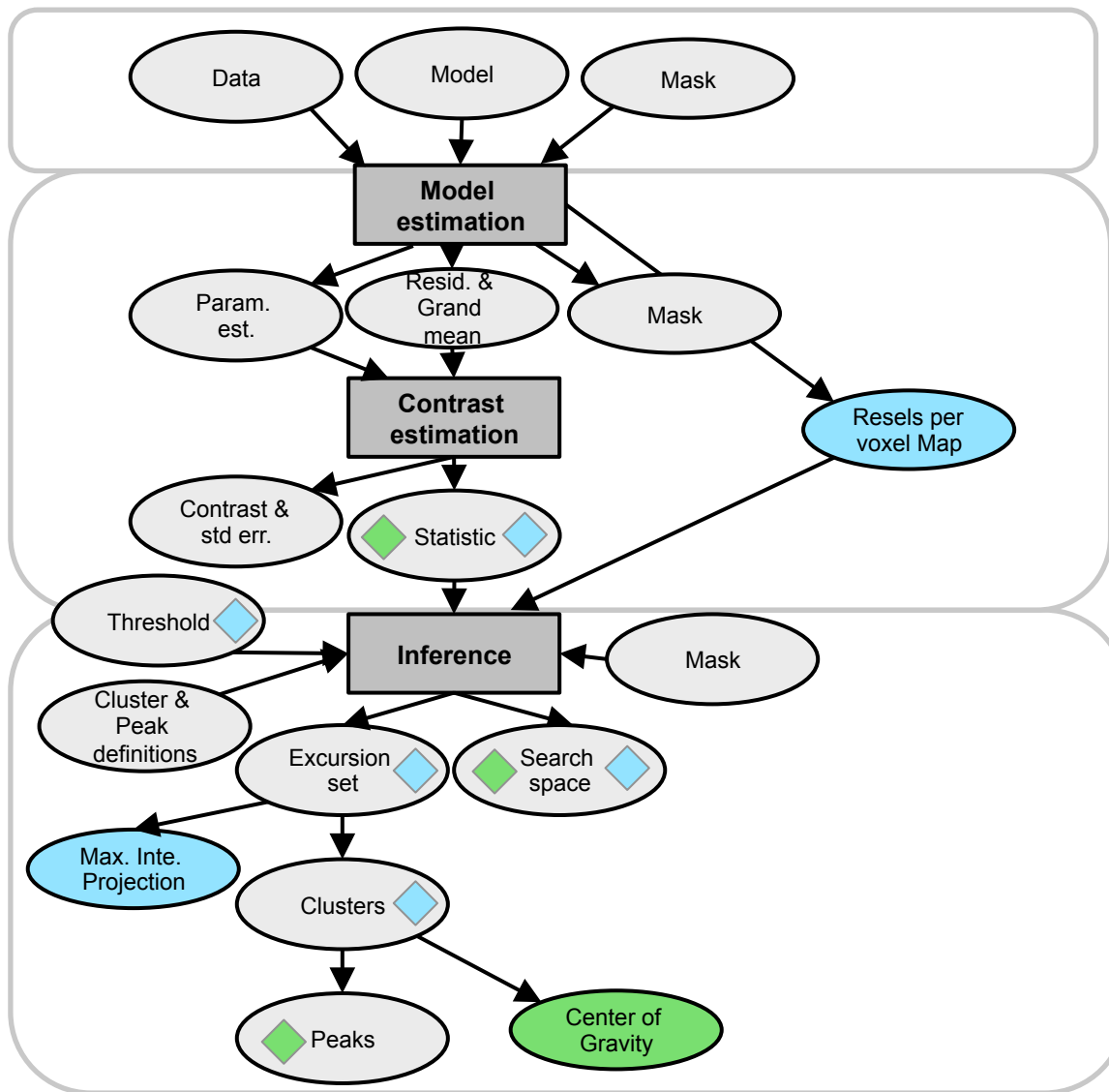
NIDM Component Layer Cake



NIDM-Results

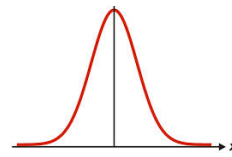


NIDM-Results: software-specific extensions

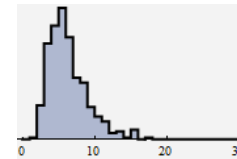


Standardization across software

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

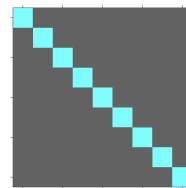


Gaussian

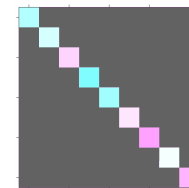


Non-Parametric

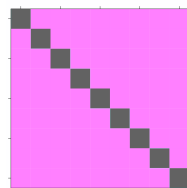
...



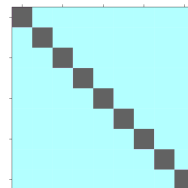
homogeneous



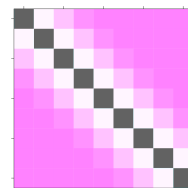
heterogeneous



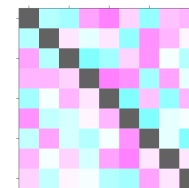
Independent noise



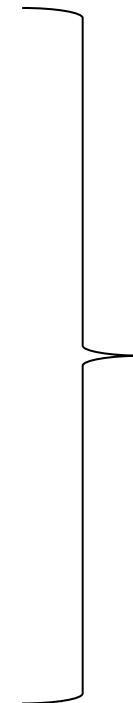
Compound Symmetry



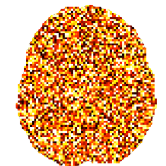
Serially correlated



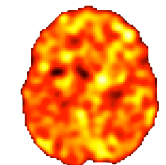
Arbitrarily correlated



global



local



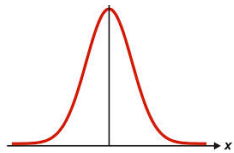
regularized

Error models : SPM, FSL and AFNI

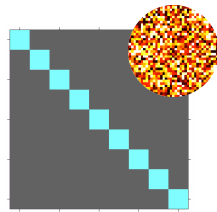
1st level

2nd level

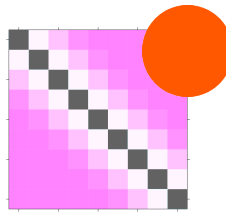
SPM



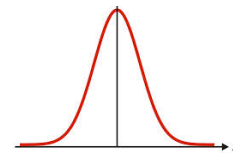
Gaussian



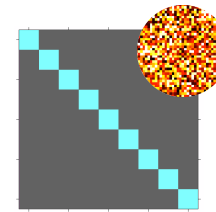
Homogeneous local



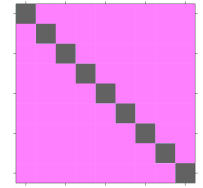
Serial. corr. global



Gaussian

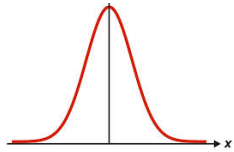


Homogeneous local

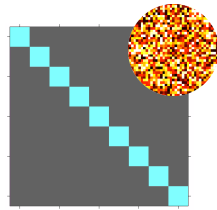


Independent noise

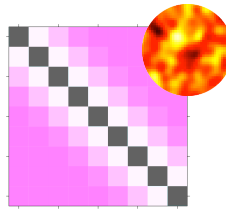
FSL



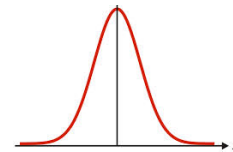
Gaussian



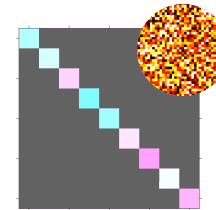
Homogeneous local



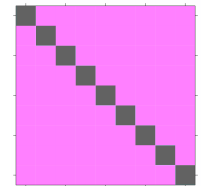
Serial. corr. regularized



Gaussian

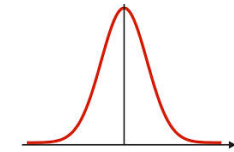


Heterogeneous local

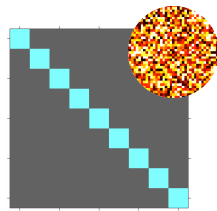


Independent noise

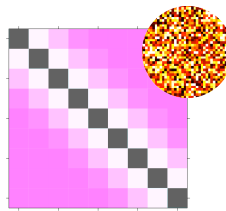
AFNI



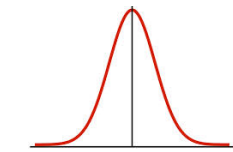
Gaussian



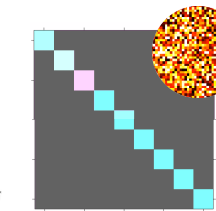
Homogeneous local



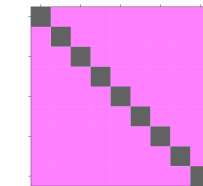
Serial. corr. local



Gaussian



Hetero- or Homogeneous local



Independent noise

Error models: non-parametric

2nd level: Sign-flipping

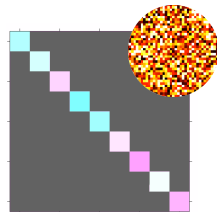
2nd level: Label permutation



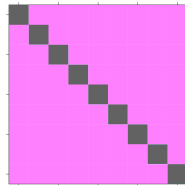
Randomise



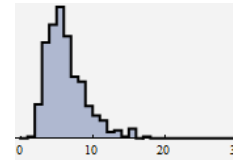
NonParametric
Symmetric



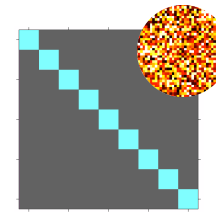
Heterogeneous
local



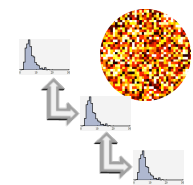
Independent
noise



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.



Dublin Core®

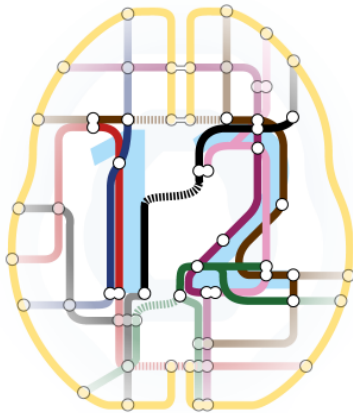


NIDM FOR META-ANALYSIS

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

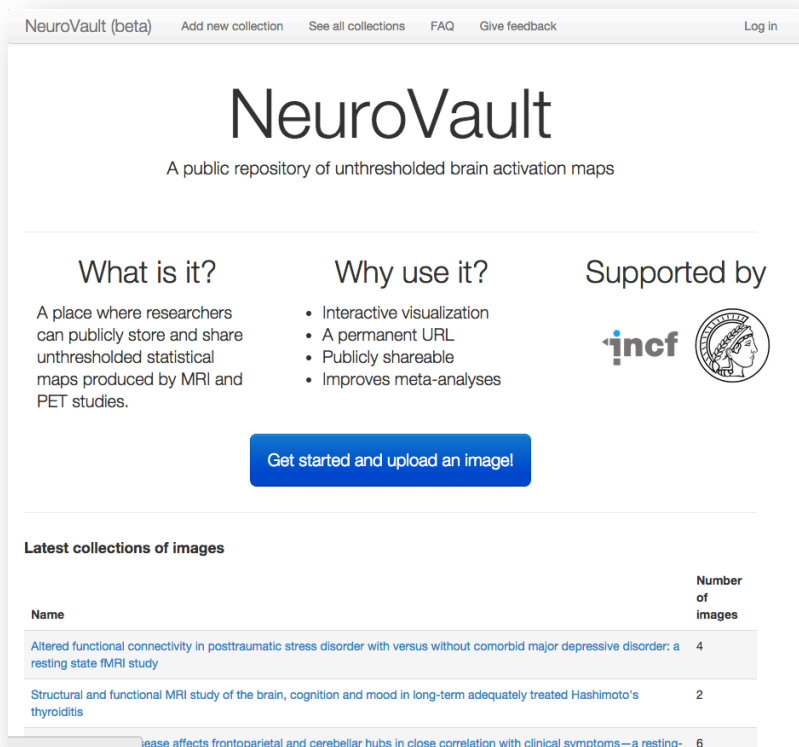
Next steps and future plans

- 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

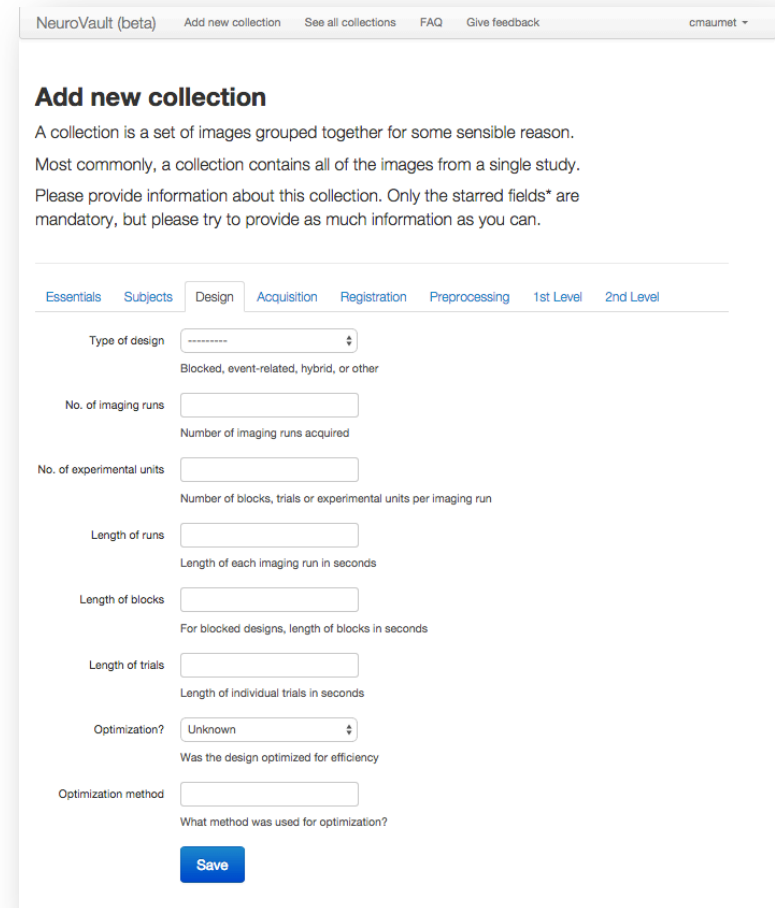
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Latest collections of images

| 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 |
| ...lease 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

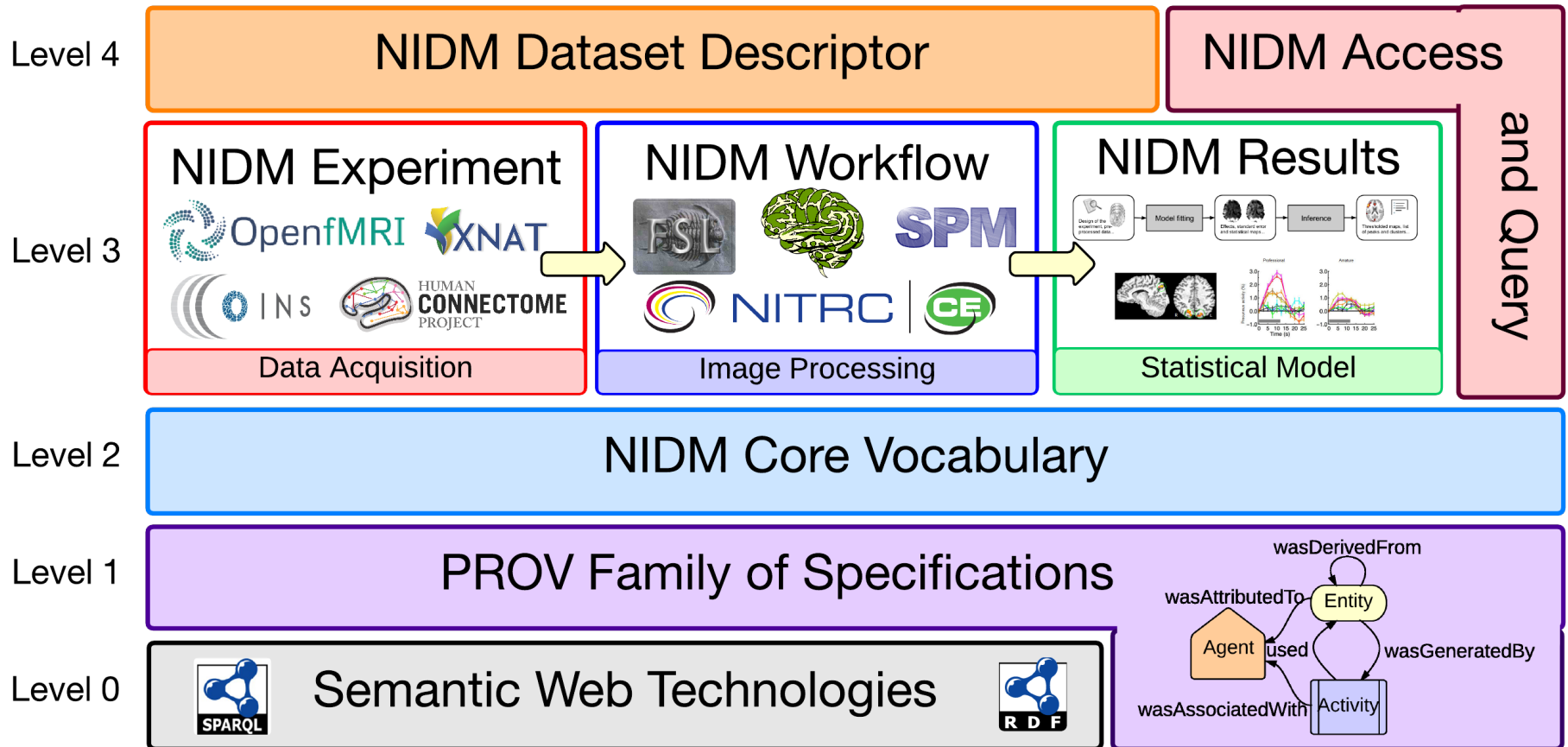
Optimization?
Was the design optimized for efficiency

Optimization method
What method was used for optimization?

[Save](#)

NIDM effort

NIDM Component Layer Cake



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. A study involving other modalities (such as PET) and sequences (e.g. anatomical MRI through VBM) can also be modelled. The results are represented in .

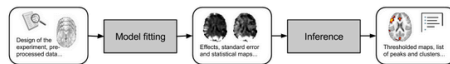


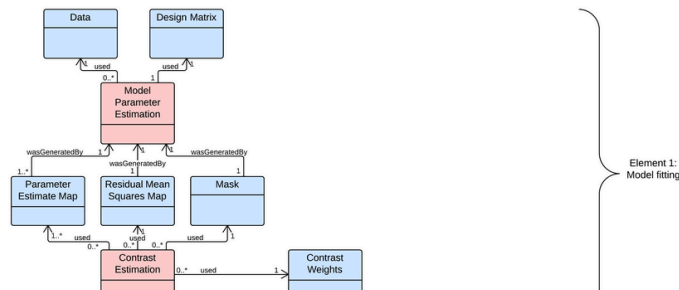
Fig. 2 Domain overview

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:Activity) "Model fitting" and "Inference", the structures and relations belonging to each element are presented in details in and .



- Create a definition for "Resel"** nidm-results Terms #128
Opened by cmaumet updated 3 hours ago 2 comments
- Defintion of "ConjunctionInference"** nidm-results Terms #134
Opened by cmaumet updated 3 days ago 1 comment

NIDM-Results Terms curation status

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

Classes

| 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. |

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NIDM working group

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welcometrust

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 {
```

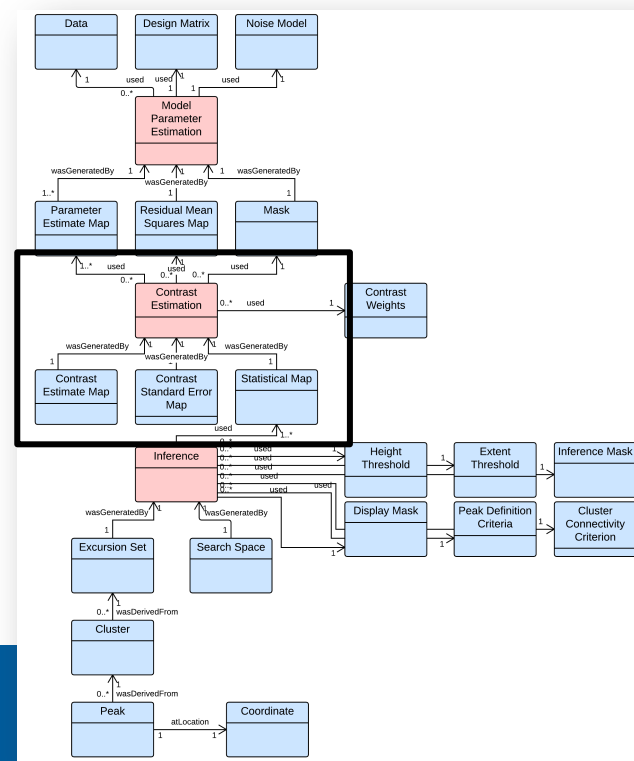
```
  ?cid a nidm:ContrastMap ;  
  nidm:contrastName ?contrastName ;  
  prov:atLocation ?contrastFile .
```

```
  ?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>