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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

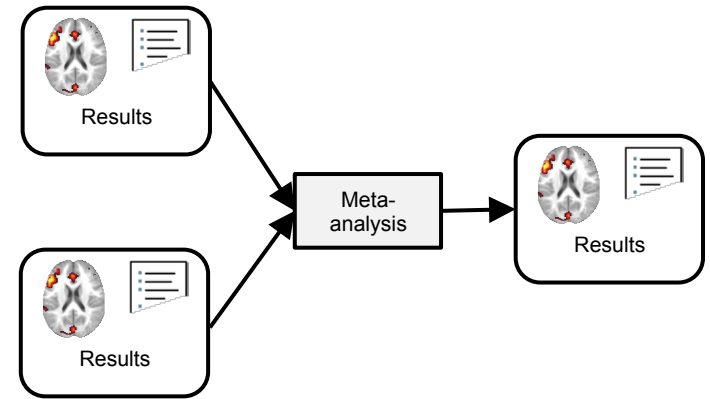
Camille Maumet

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

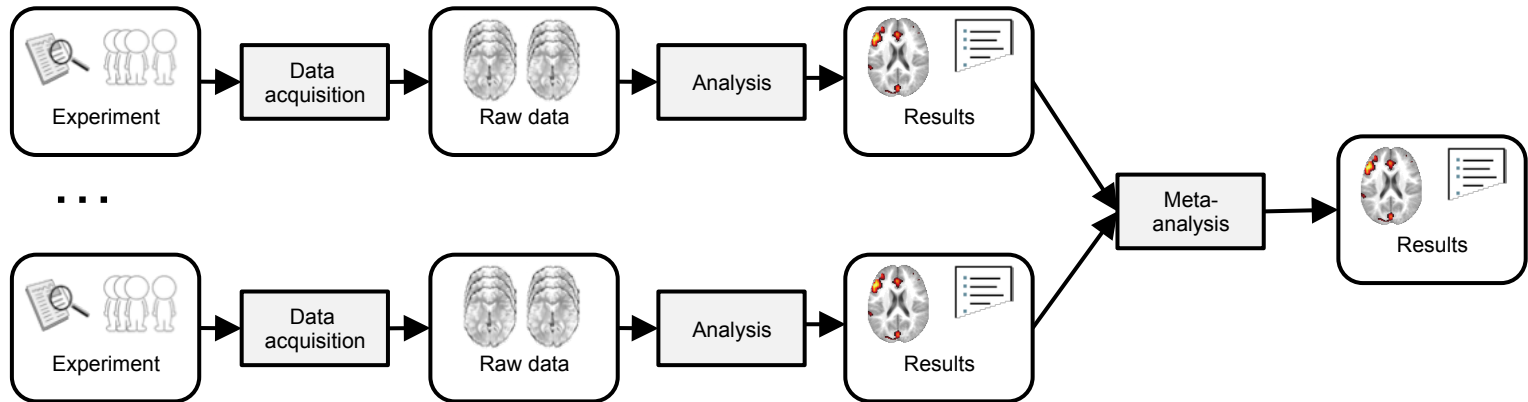
# CONTEXT



CONTEXT

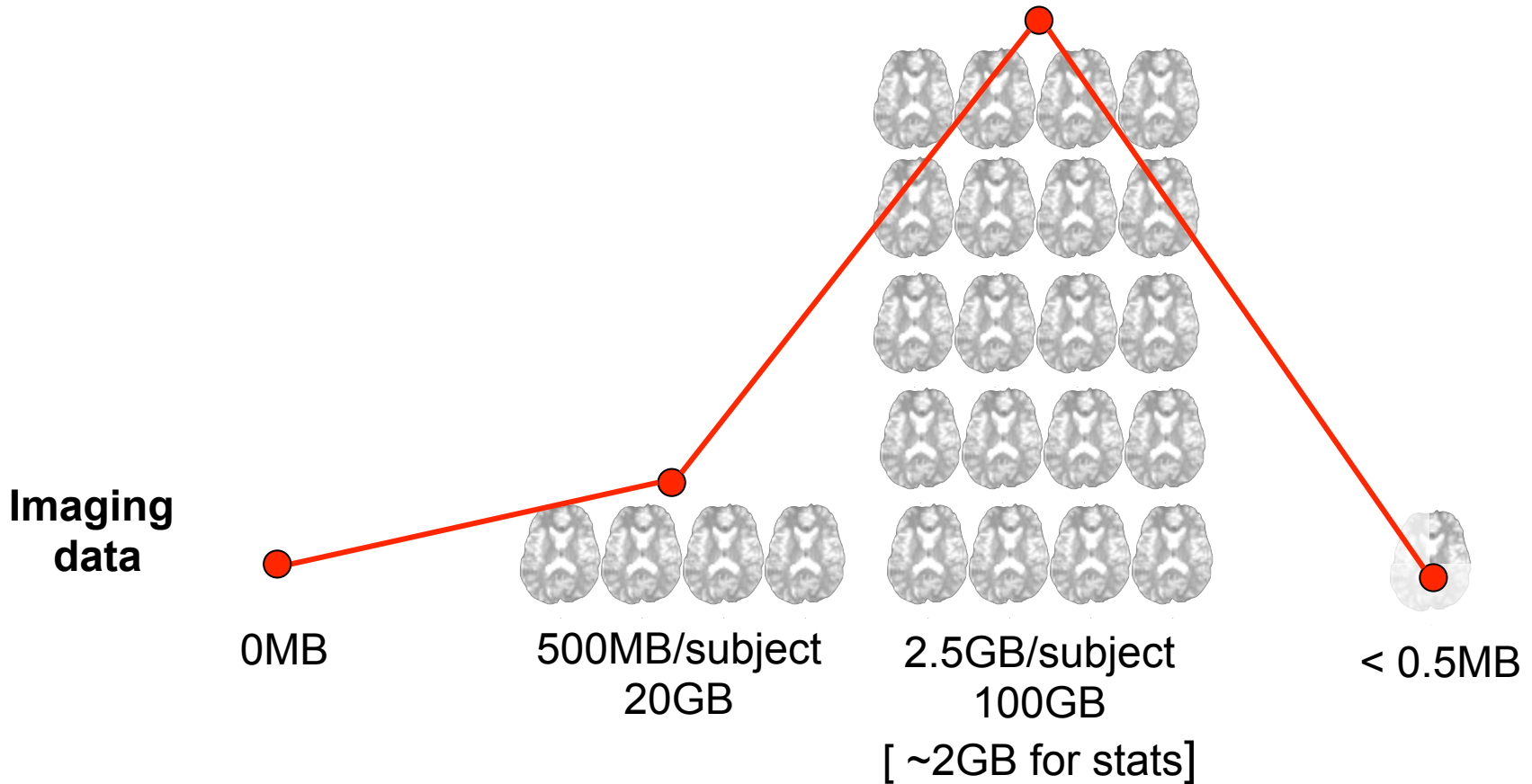
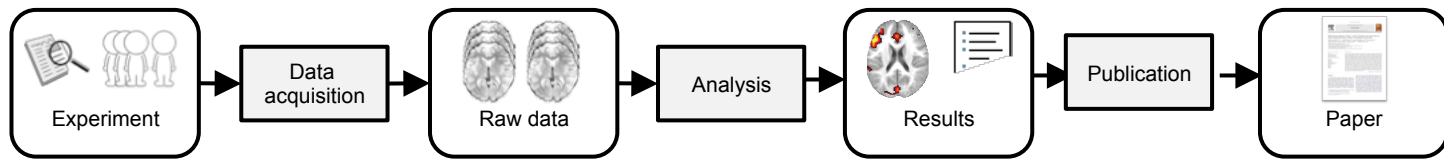
# Meta-analysis in neuroimaging

# Why meta-analyses?

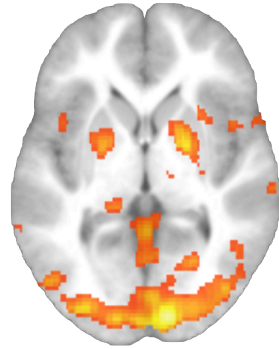
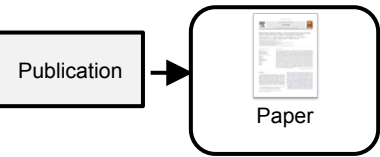


- Increase statistical power
- Combine information across studies

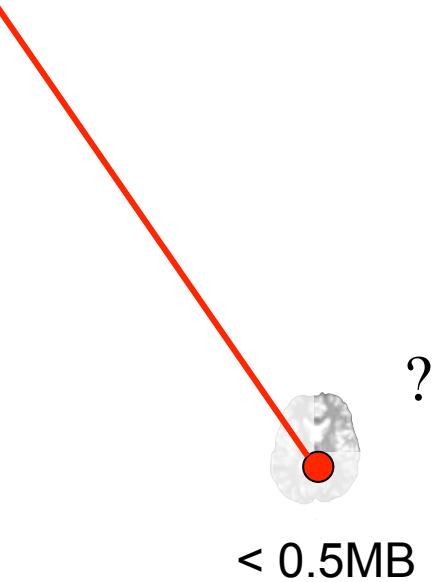
# Data analysis in neuroimaging



# Data analysis in neuroimaging



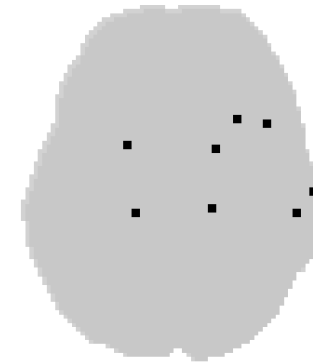
Detection images  
(qualitative)



**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 <sup>(4)</sup>	--	825
Precentral	18-3.38 <sup>(5)</sup>	--	348-5.09	--	825
Mid frontal	33-3.66	--	--	--	--
SMA	--	--	1433-5.48	--	357
Cingulate	--	--	1433-5.08 <sup>(3)</sup>	--	--
Med sup frontal	174-4.69	--	--	--	--
Rol operculum	--	--	--	36 - 4.31	--
Insula	--	--	396-4.87 <sup>(8)</sup>	--	58-
Sup temporal	--	--	351-3.81 <sup>(1)</sup>	--	91-
Mid temporal	--	1658-4.67 <sup>(3)</sup>	351-5.61 <sup>(2)</sup>	--	10-
Inf parietal	--	1658-5.18 <sup>(6)</sup>	--	--	--
Sup parietal	--	--	--	--	976
Postcentral	--	--	--	--	976
Sup occipital	--	--	--	--	--
Mid occipital	--	--	--	146-4.43	146
Inf occipital	--	--	--	--	146
Fusiform	--	--	--	397-5.44	146

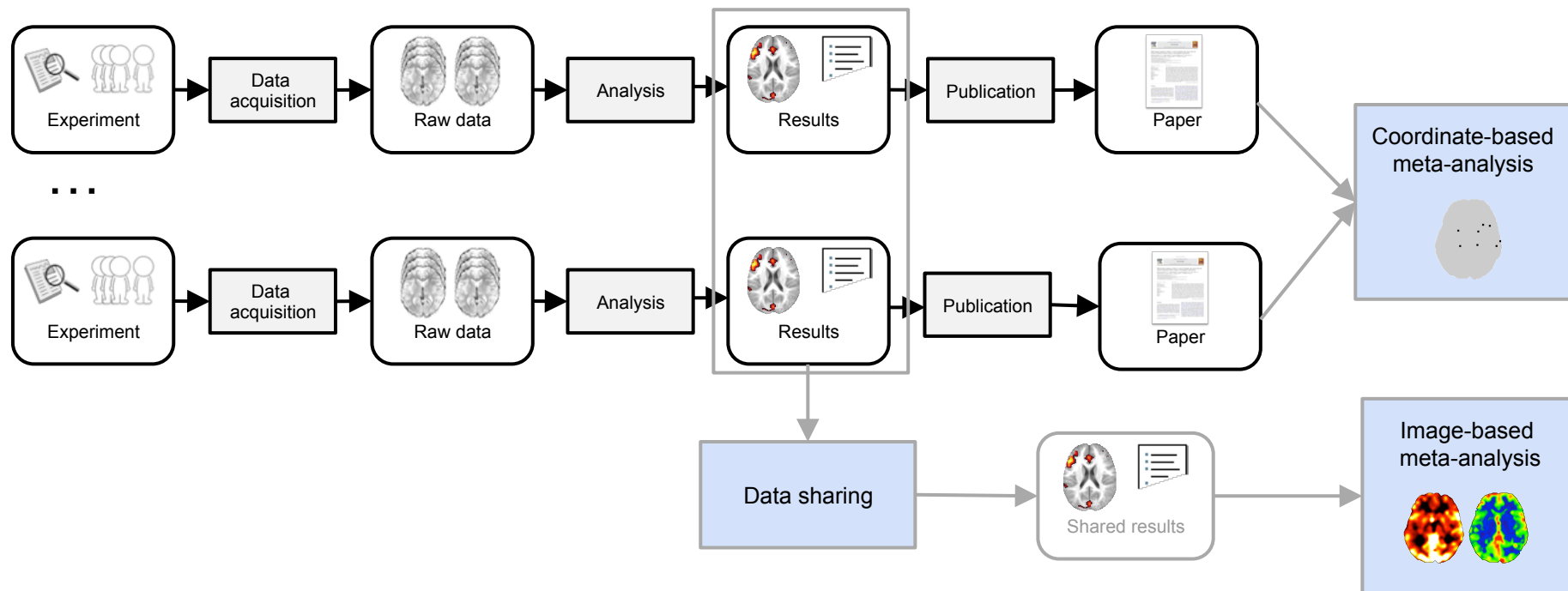
Table of local maxima  
(quantitative)



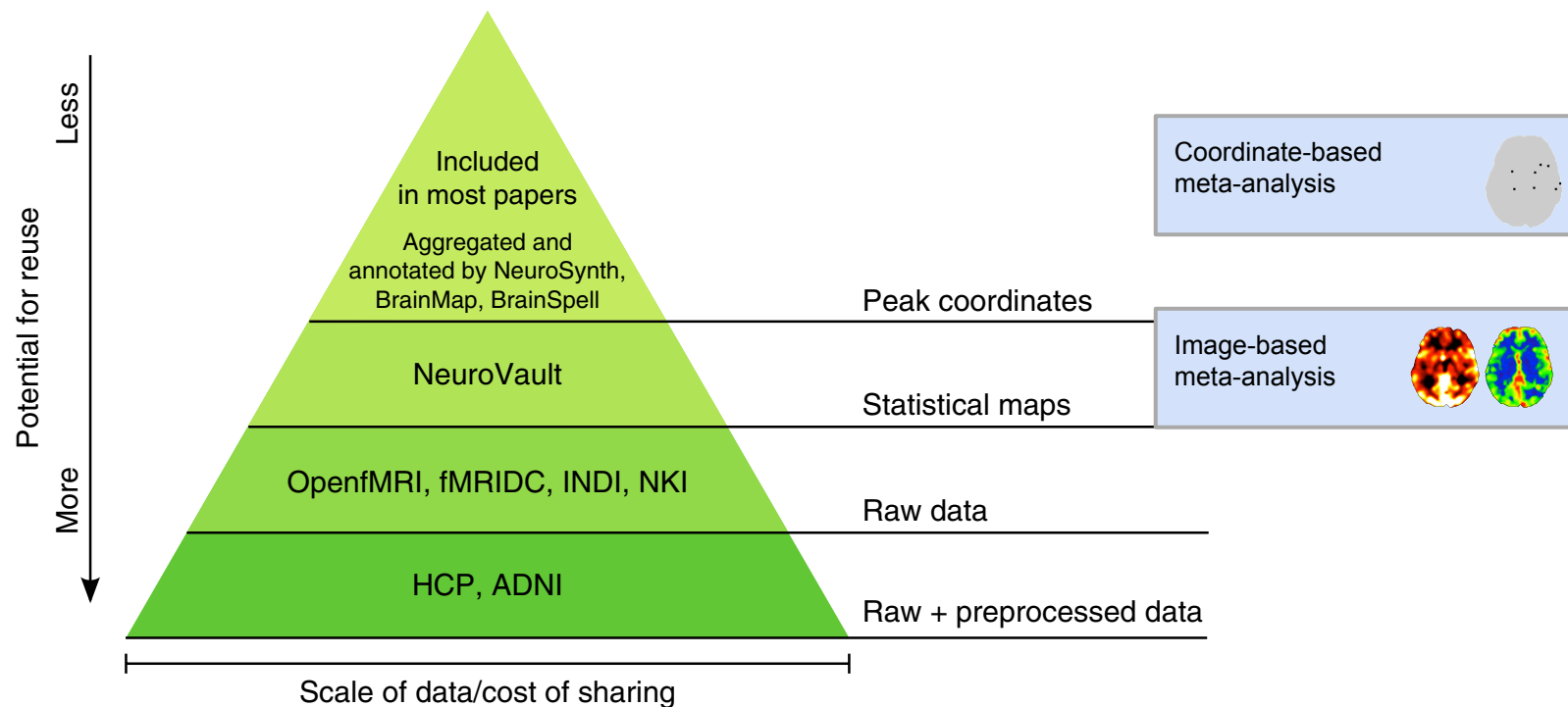
Peaks  
(quantitative)



# Coordinate- or Image-Based meta-analysis?



# Which data to share?

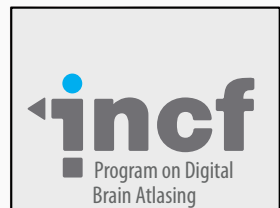


Reprinted by permission from Macmillan Publishers Ltd: Nature neuroscience (Poldrack, R. a, & Gorgolewski, K. J. (2014). Making big data open : data sharing in neuroimaging. Nature Neuroscience, 17(11). doi:10.1038/nn.3818), copyright (2014)

CONTEXT

# INCF NIDASH Task Force

# International Neuroinformatics Coordinating Facility



## Digital Brain Atlasing

Coordinates and improves the impact of brain atlasing projects



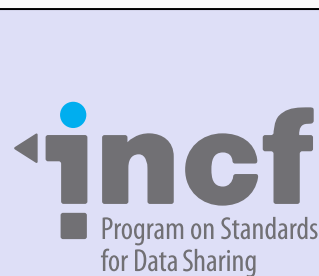
## Multiscale Modeling

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

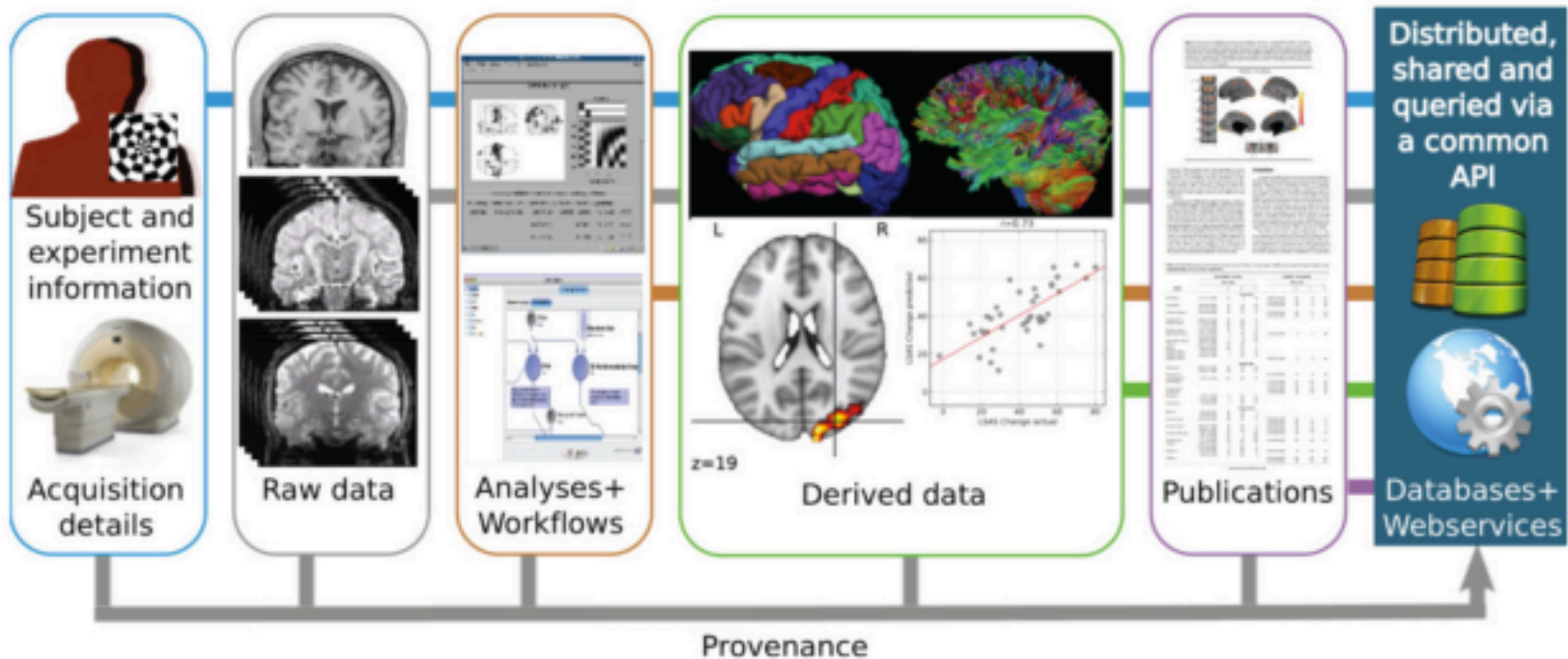
- Neuroimaging (NIDASH)
- Electrophysiology

# 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

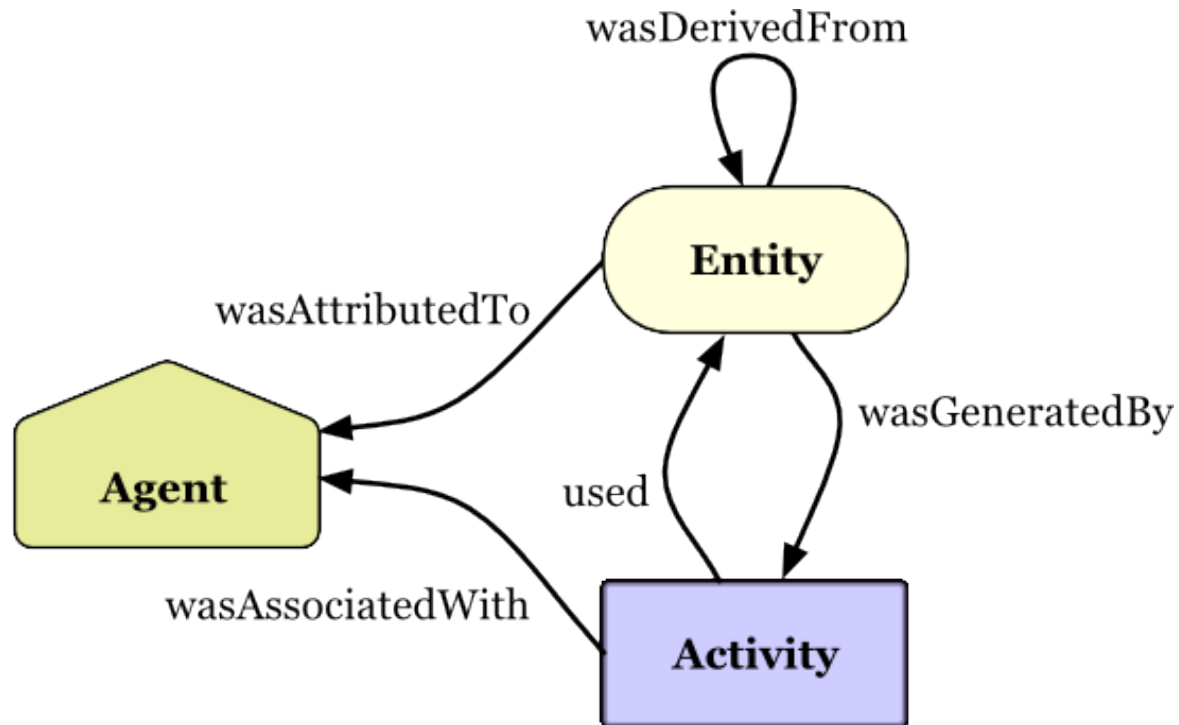


| Electronic Data Capture (EDC) workflow for data sharing in neuroimaging research.

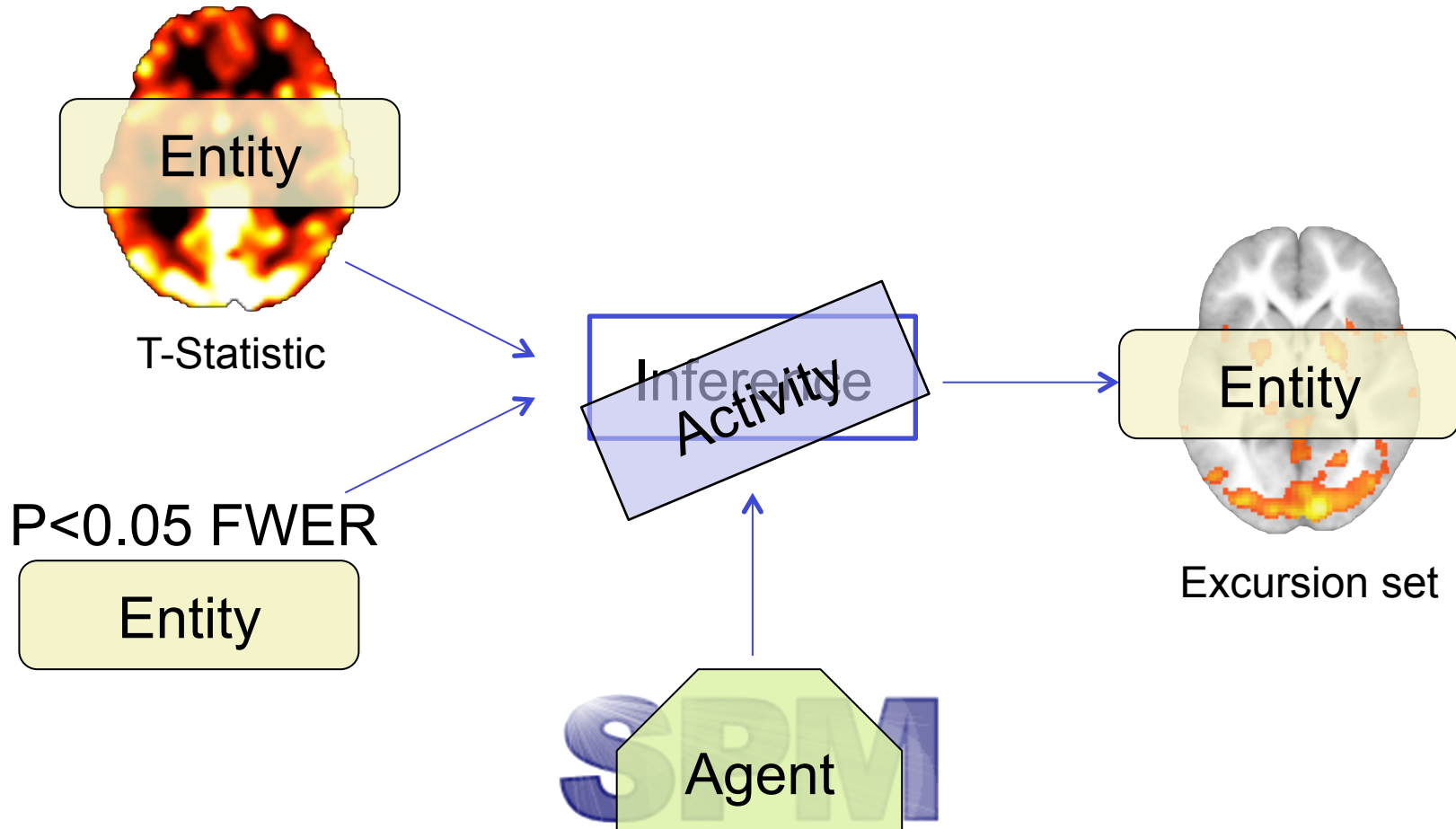
Source: Poline et al, Frontiers in Neuroinformatics (2012).

# NIDM: Neuroimaging Data Model

- Based on PROV-DM



# PROV-DM example

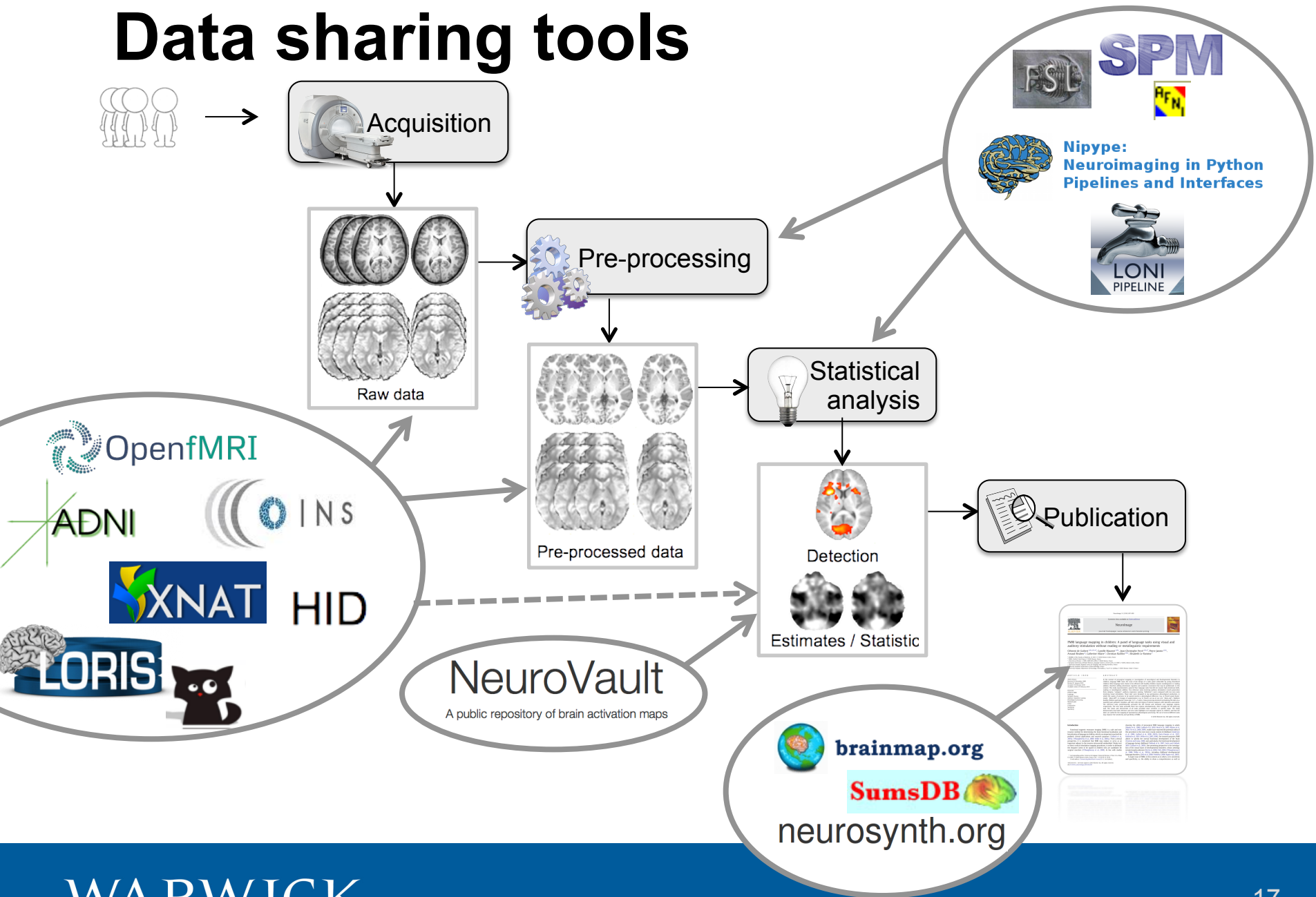




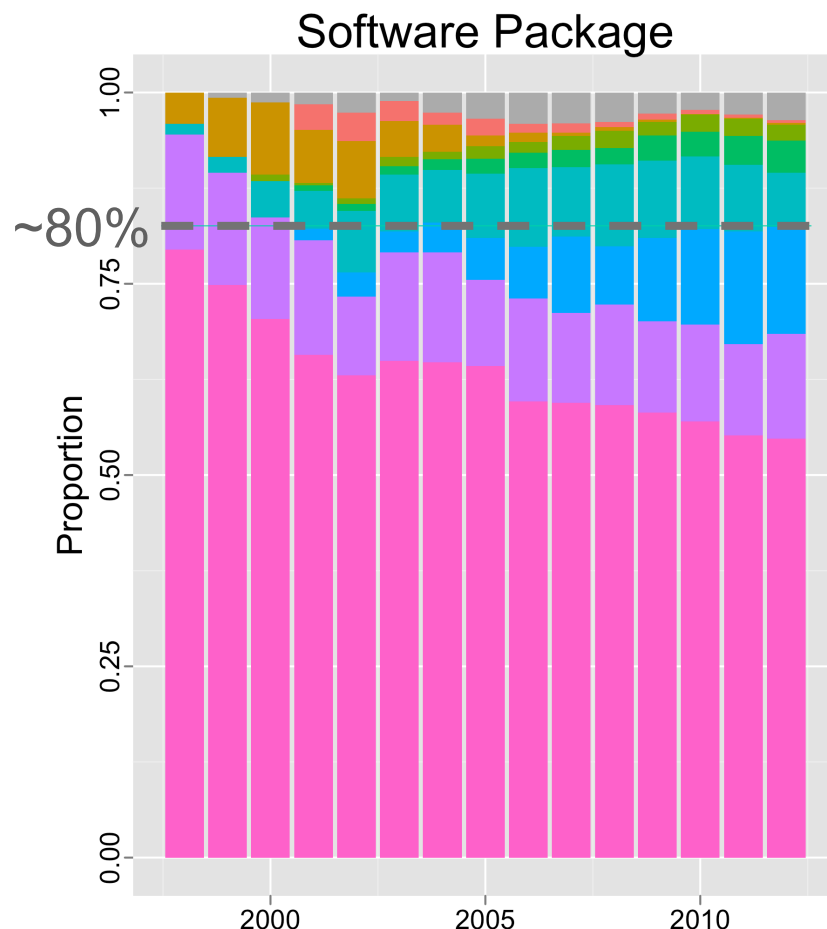
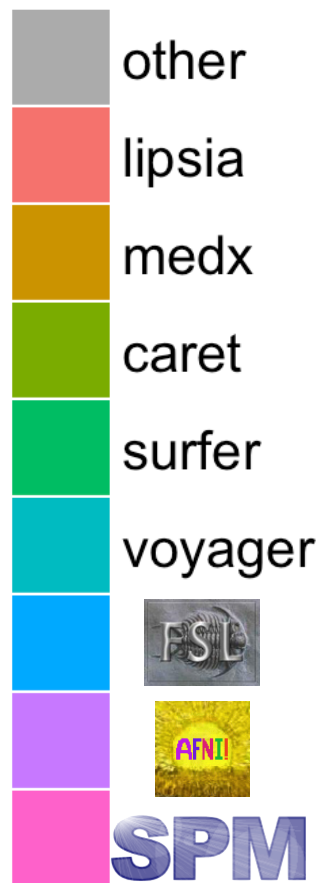
CONTEXT

# Data sharing environment

# Data sharing tools



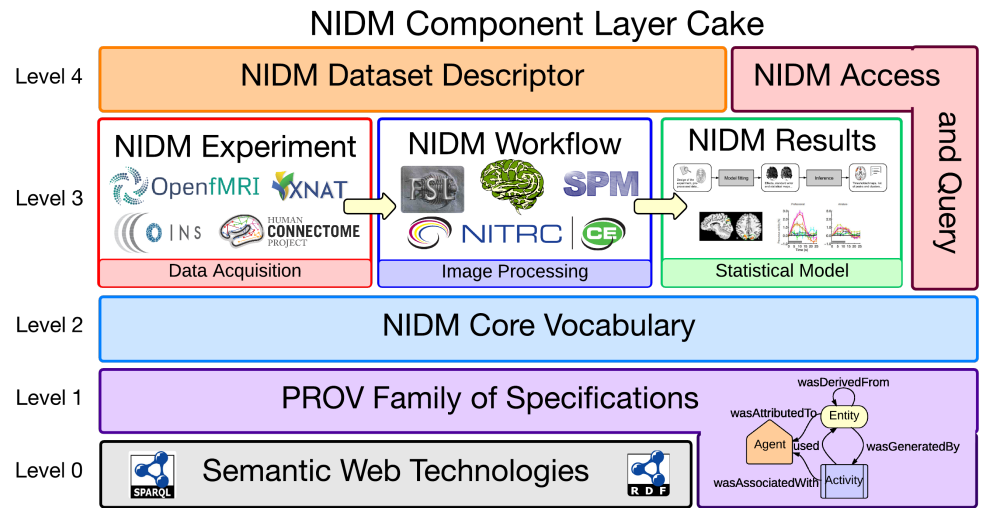
# Three major software packages



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>

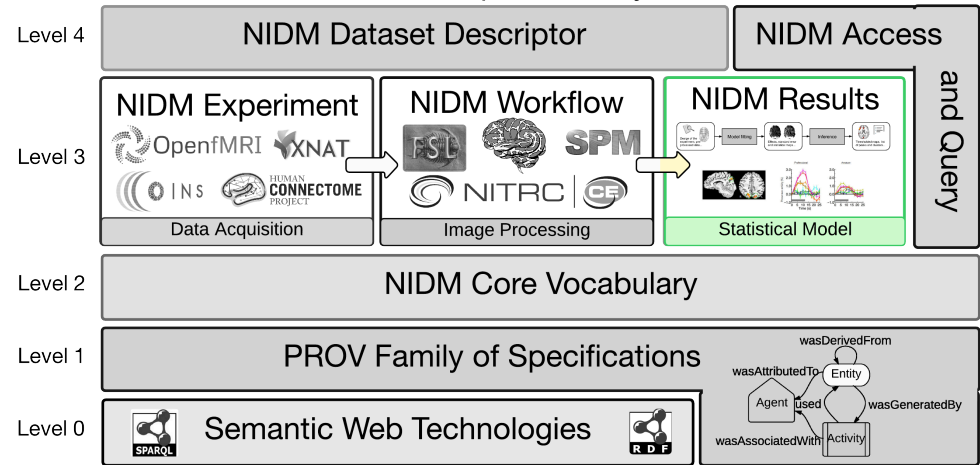
# Summary of the problem

- 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

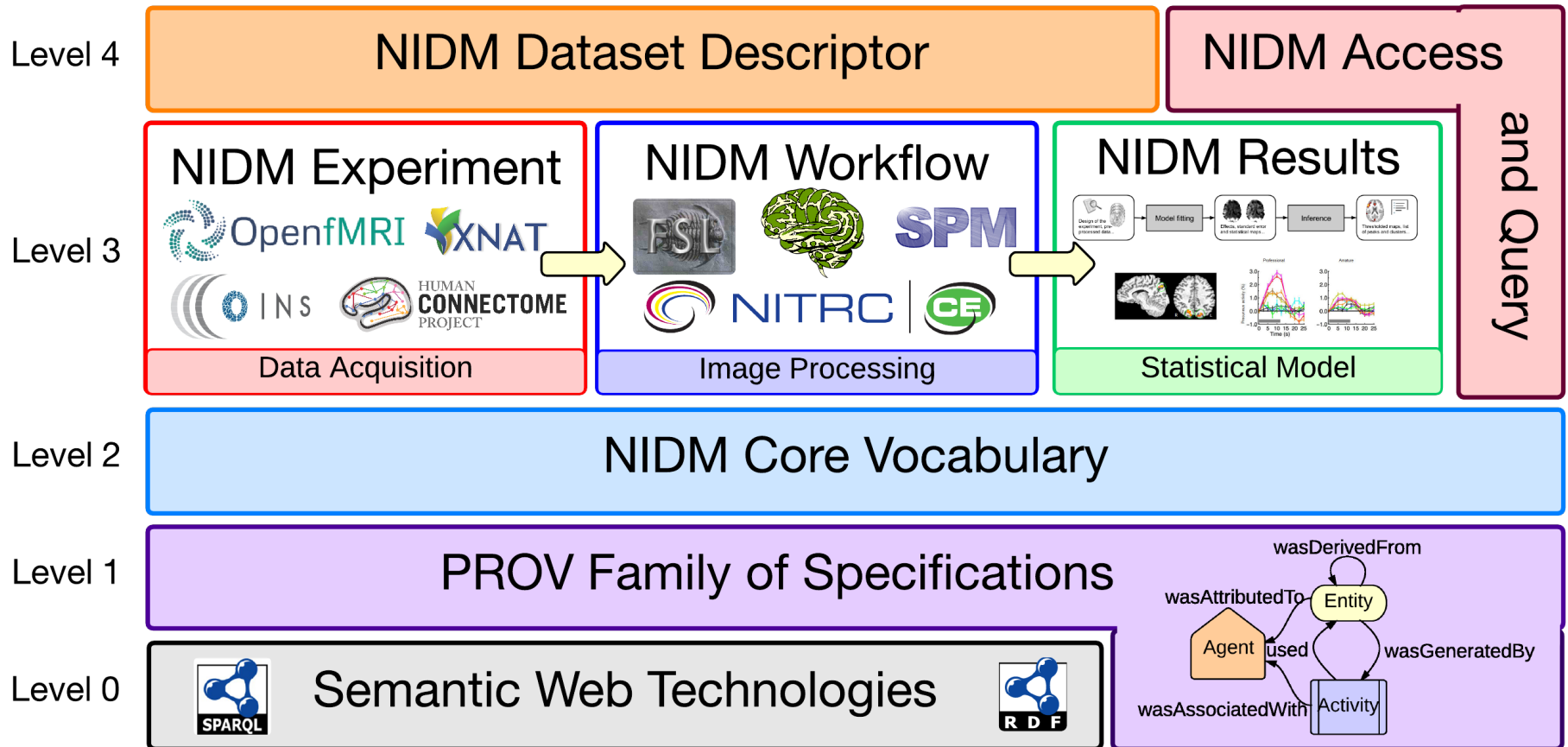


NIDM FOR META-ANALYSIS

# NIDM-Results

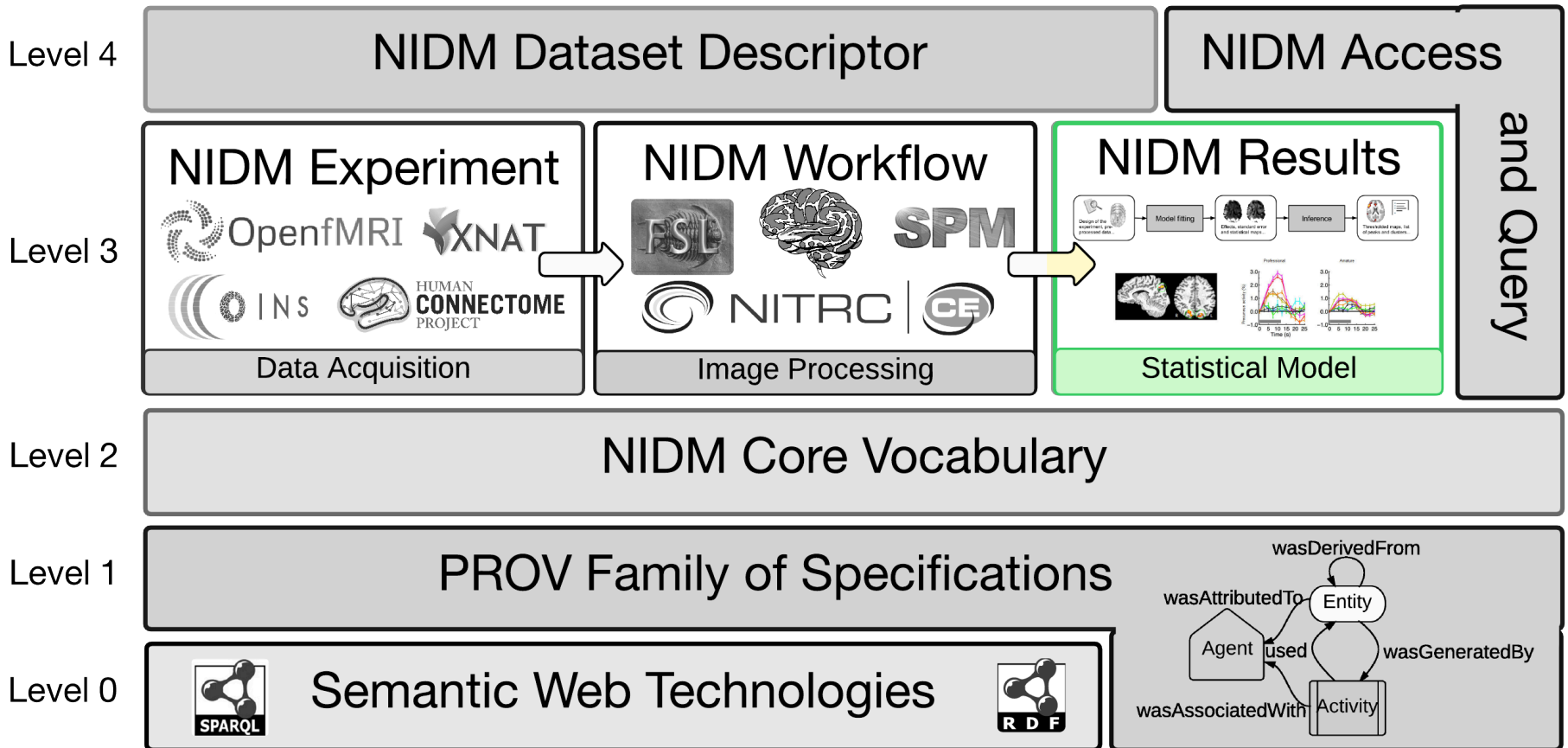
# Neuroimaging Data Model

## NIDM Component Layer Cake



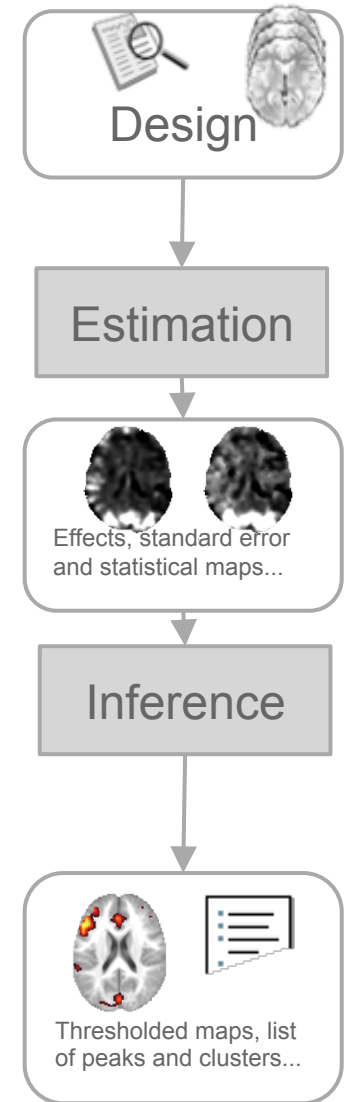
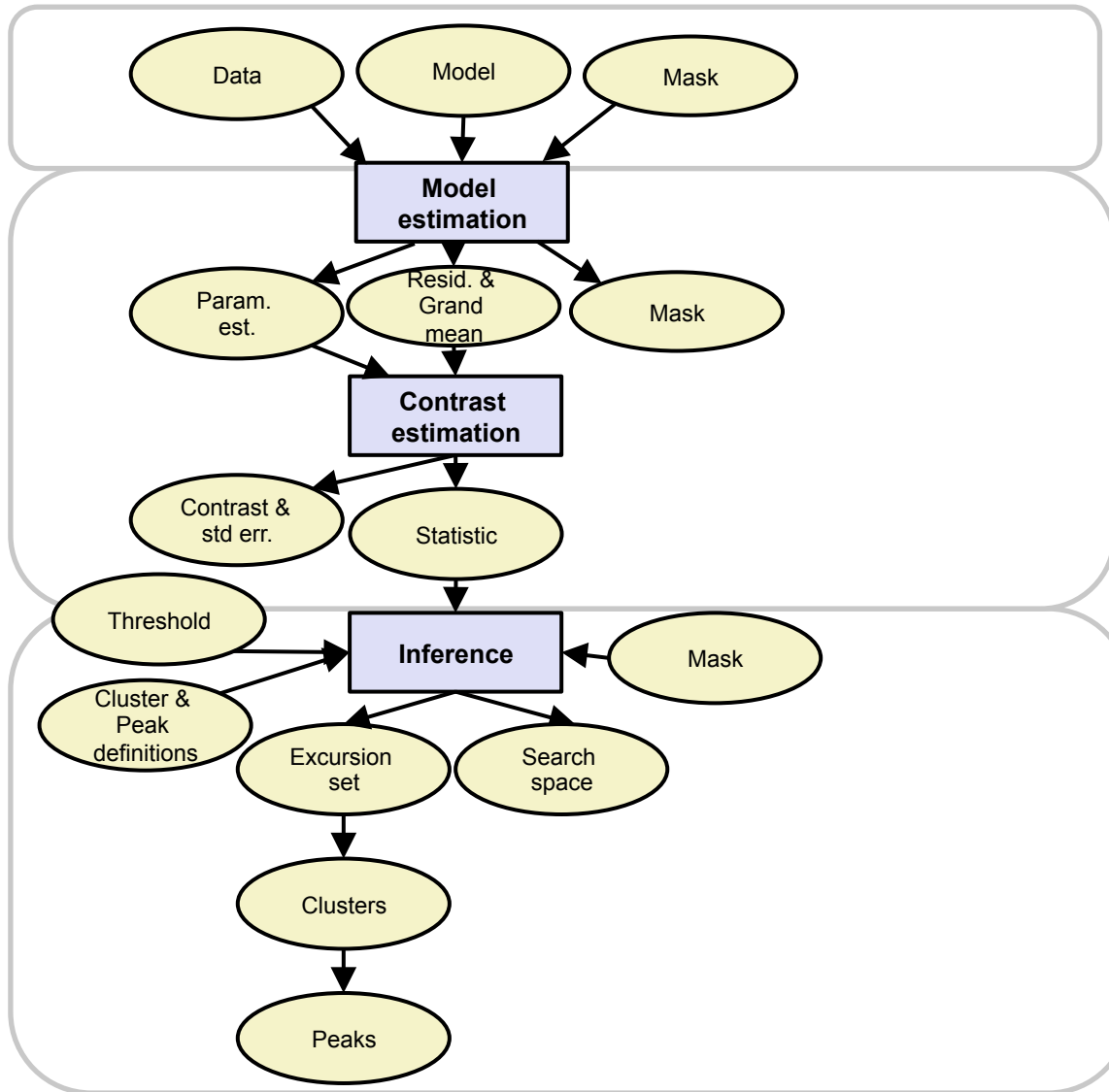
# NIDM-Results

## NIDM Component Layer Cake

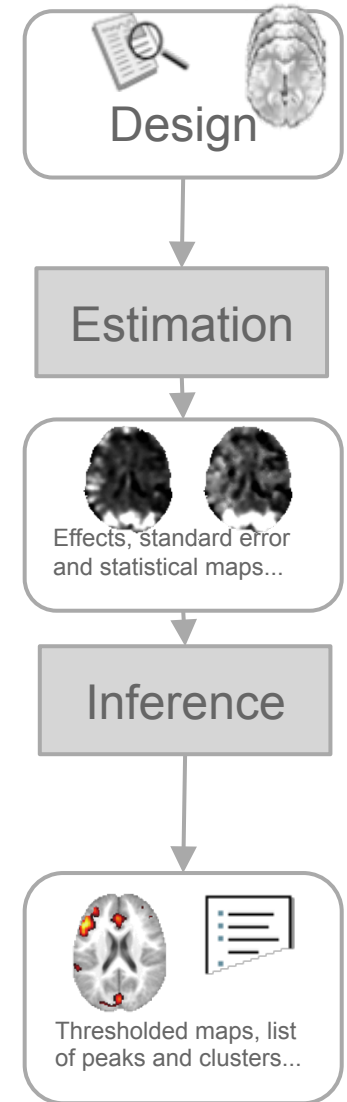
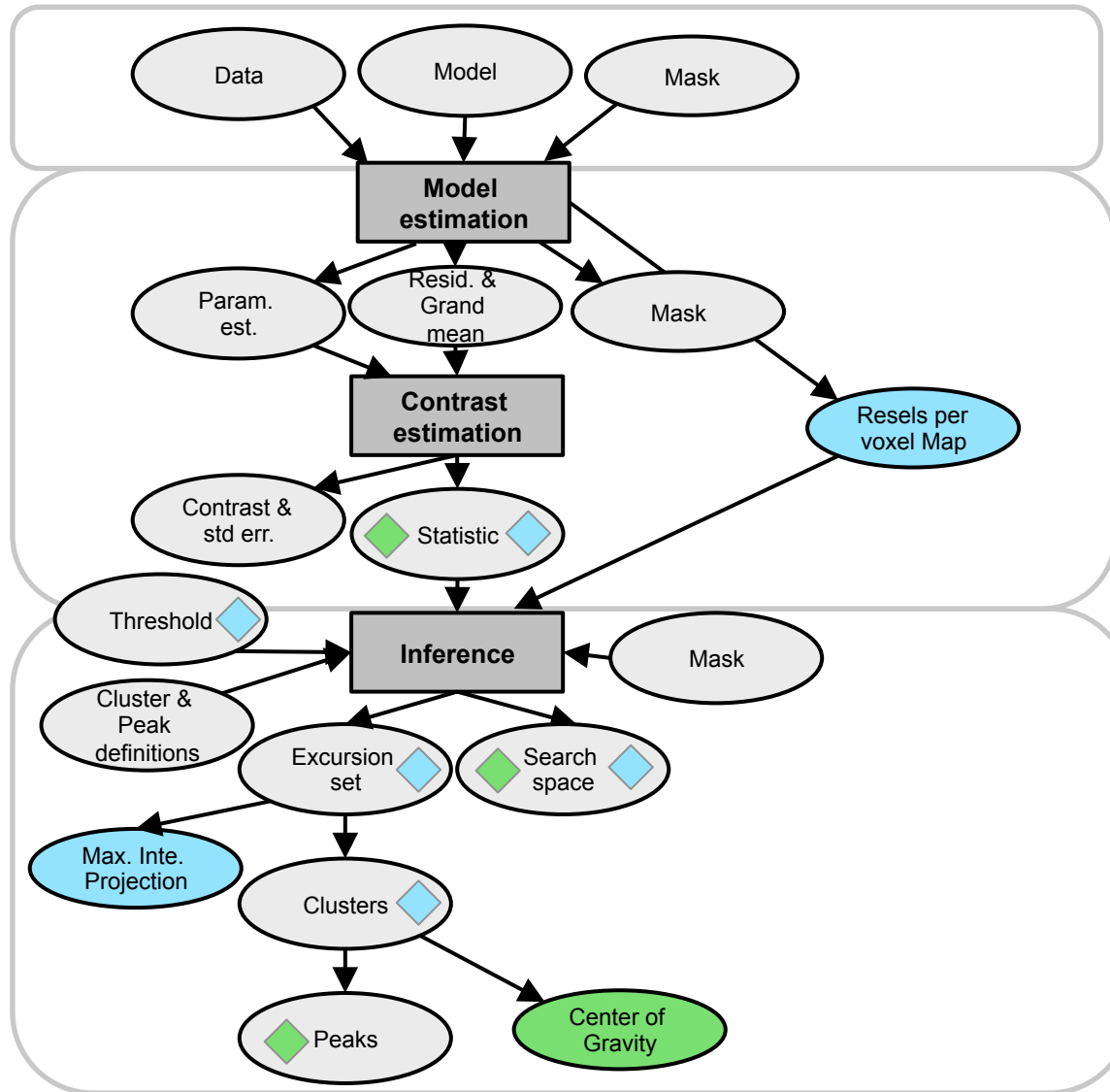




# NIDM-Results

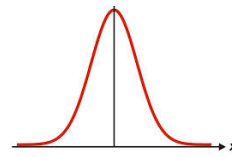


# NIDM-Results: software-specific extensions

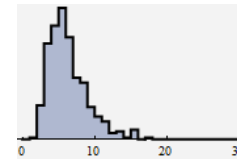


# Standardization across software

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

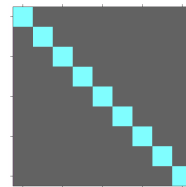


Gaussian

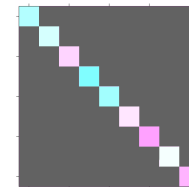


Non-Parametric

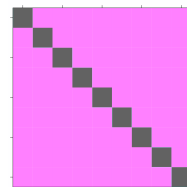
...



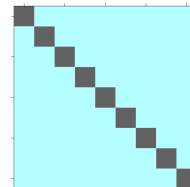
homogeneous



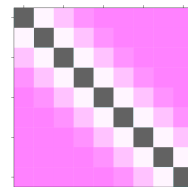
heterogeneous



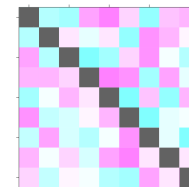
Independent noise



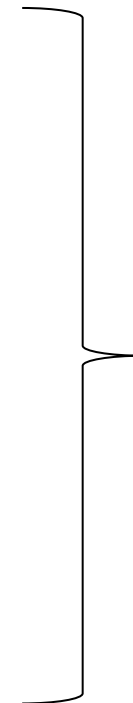
Compound Symmetry



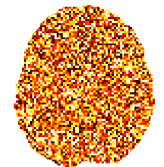
Serially correlated



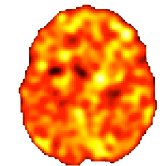
Arbitrarily correlated



global



local



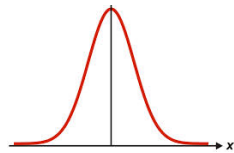
regularized

# Error models : SPM, FSL and AFNI

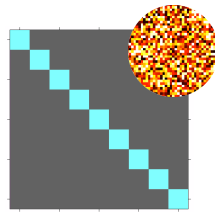
1<sup>st</sup> level

2<sup>nd</sup> level

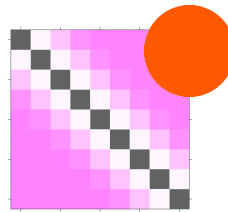
SPM



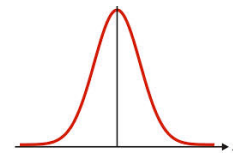
Gaussian



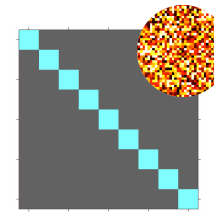
Homogeneous local



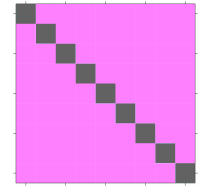
Serial. corr. global



Gaussian

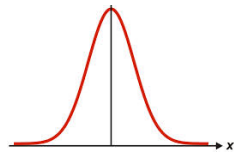


Homogeneous local

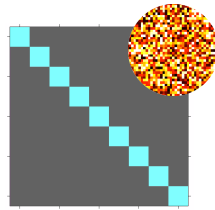


Independent noise

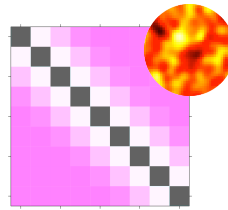
FSL



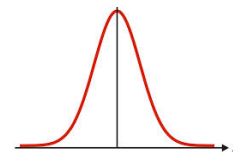
Gaussian



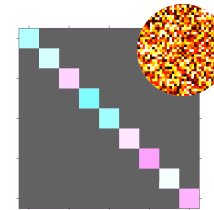
Homogeneous local



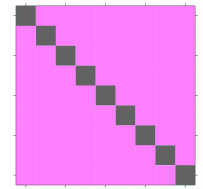
Serial. corr. regularized



Gaussian

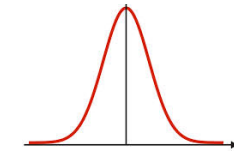


Heterogeneous local

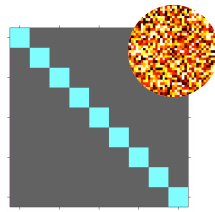


Independent noise

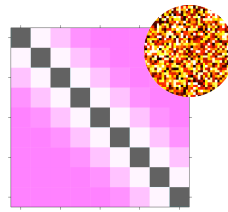
AFNI



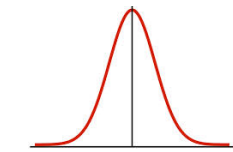
Gaussian



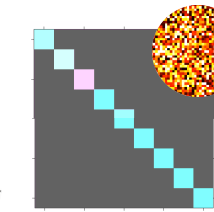
Homogeneous local



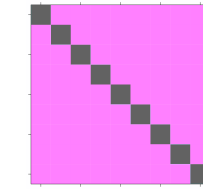
Serial. corr. local



Gaussian



Hetero- or Homogeneous local



Independent noise

# Error models: non-parametric

2<sup>nd</sup> level: Sign-flipping

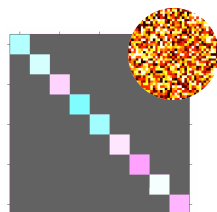
2<sup>nd</sup> level: Label permutation



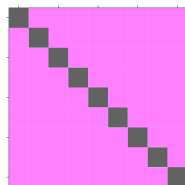
Randomise



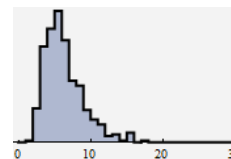
NonParametric  
Symmetric



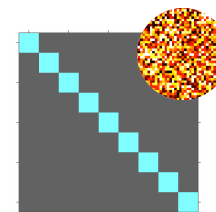
Heterogeneous  
local



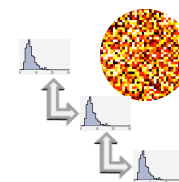
Independent  
noise



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®

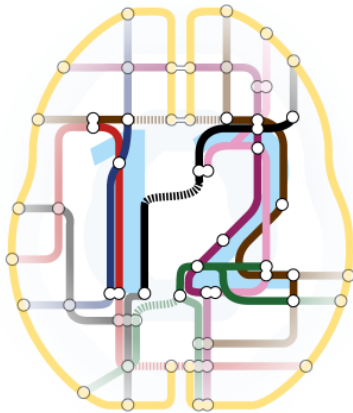


NIDM FOR META-ANALYSIS

# Implementation

# Implementation

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





NIDM FOR META-ANALYSIS

# **Future directions**

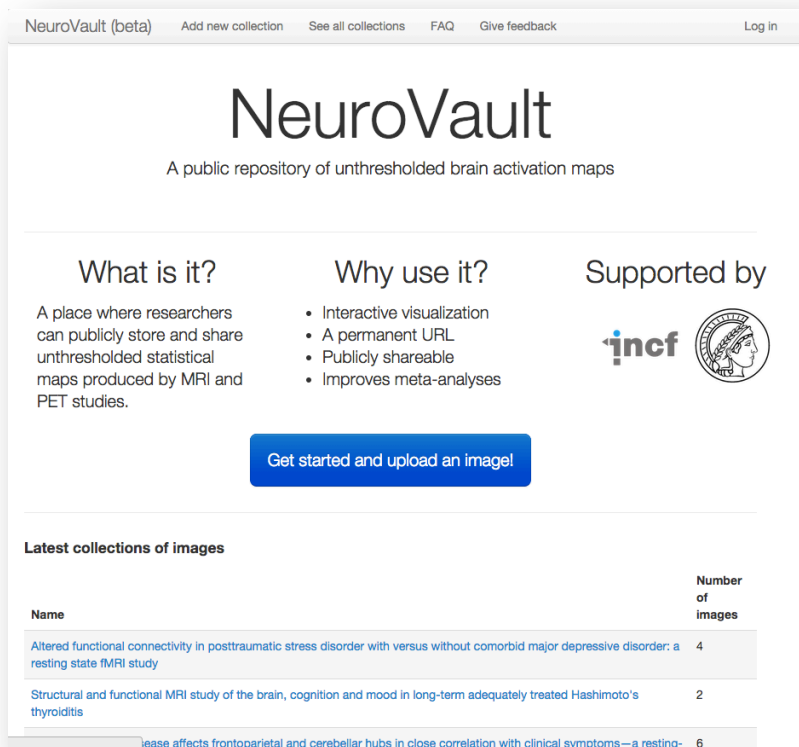
# Next steps and future plans

- 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

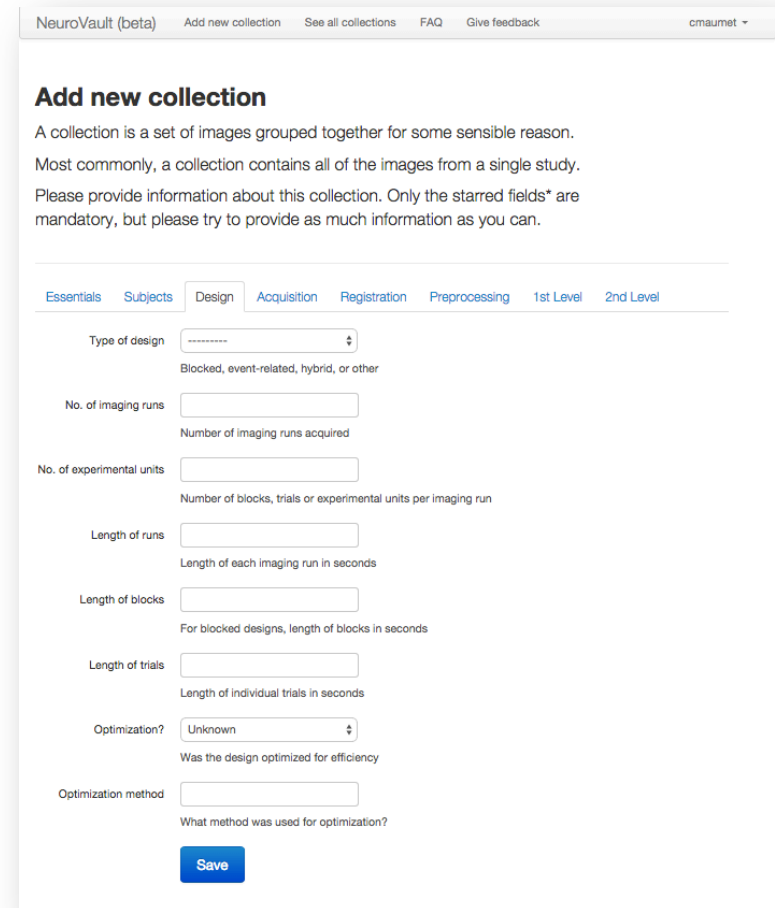
### Supported by



[Get started and upload an image!](#)

#### Latest collections of images

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

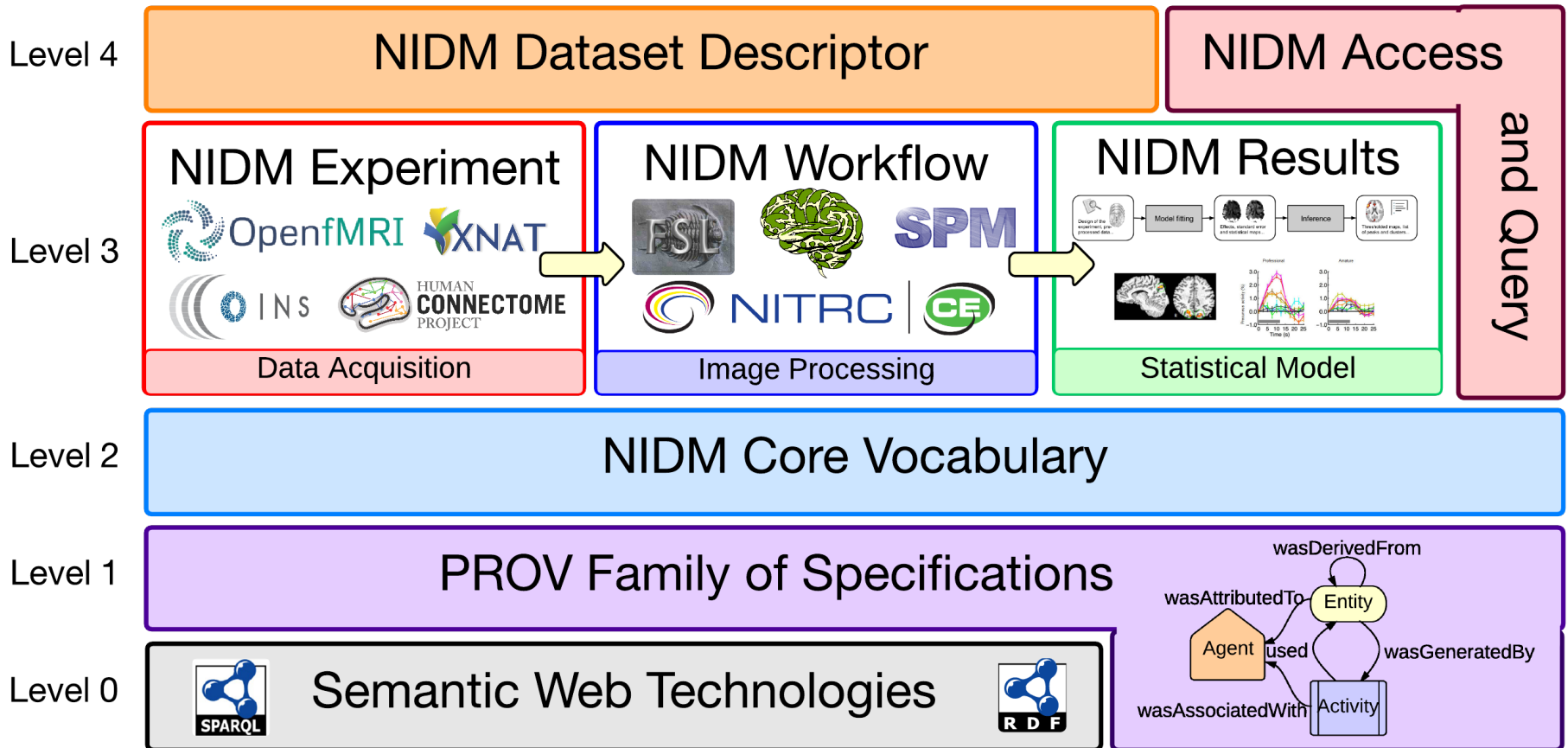
Optimization?  Was the design optimized for efficiency

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 .

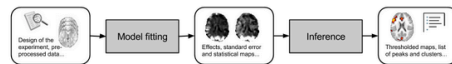


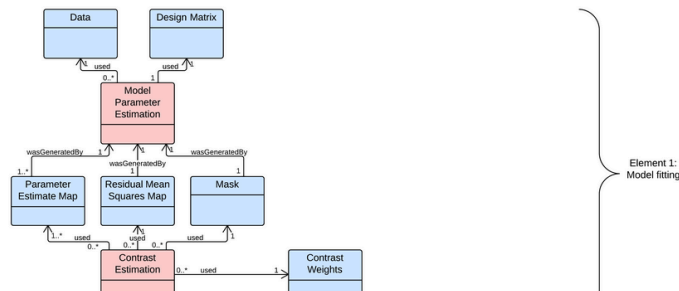
Fig. 2 Domain overview

### 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
<span style="color: green;">■</span>	<b>fsl:ZStatisticMap</b> : A map whose value at each location is a Z-statistic value.
<span style="color: green;">■</span>	<b>nidm:ContrastMap</b> : A map whose value at each location is statistical contrast estimate.

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### **NIDM working group**

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### **INCF NIDASH - Other members**

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This work is supported by the

**welcome**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#>>

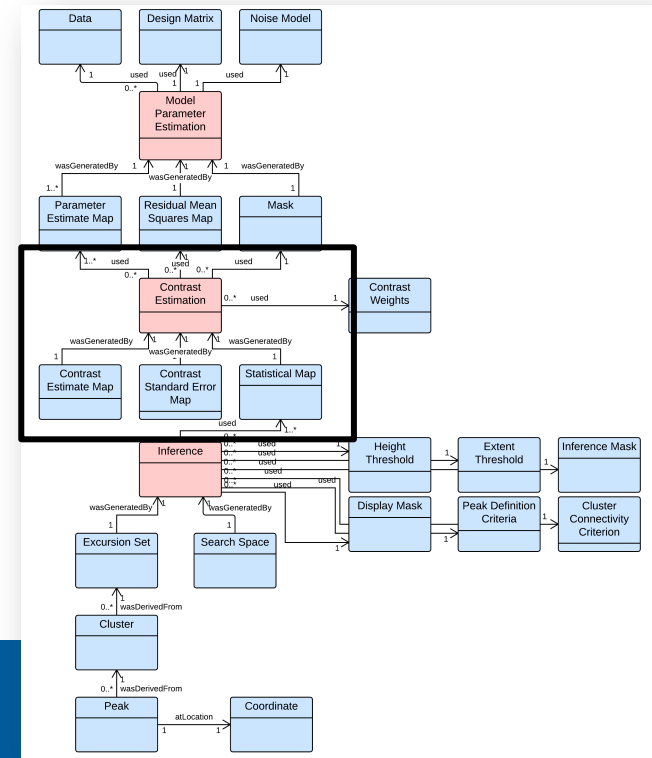
prefix nidm: <<http://www.incf.org/ns/nidash/nidm#>>

```
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>