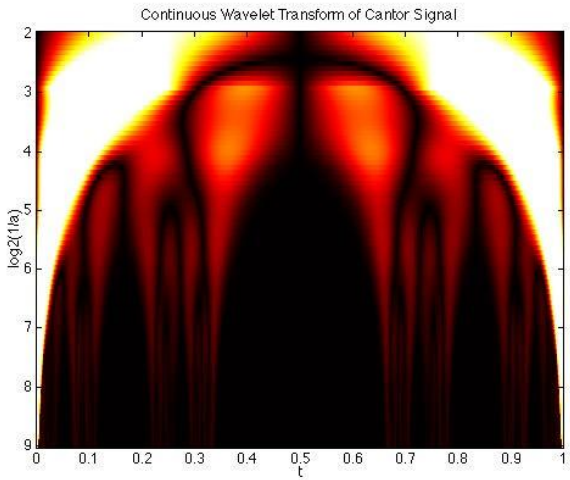
SPM

SPM and Data Sharing

Guillaume Flandin
Wellcome Trust Centre for Neuroimaging
University College London

Brainhack
Warwick, 3rd March 2017

Reproducible Research



WaveLab and Reproducible Research

Jonathan B. Buckheit and David L. Donoho

Stanford University, Stanford CA 94305, USA

Abstract

WaveLab is a library of Matlab routines for wavelet analysis, wavelet-packet analysis, cosine-packet analysis and matching pursuit. The library is available free of charge over the Internet. Versions are provided for Macintosh, UNIX and Windows machines.

WaveLab makes available, in one package, all the code to reproduce all the figures in our published wavelet articles. The interested reader can inspect the source code to see exactly what algorithms were used, how parameters were set in producing our figures, and can then modify the source to produce variations on our results. WaveLab has been developed, in part, because of exhortations by Jon Claerbout of Stanford that computational scientists should engage in "really reproducible" research.

*"An article about computational science in a scientific publication is **not** the scholarship itself, it is merely **advertising** of the scholarship. The actual scholarship is the complete software development environment and the complete set of instructions which generated the figures."*

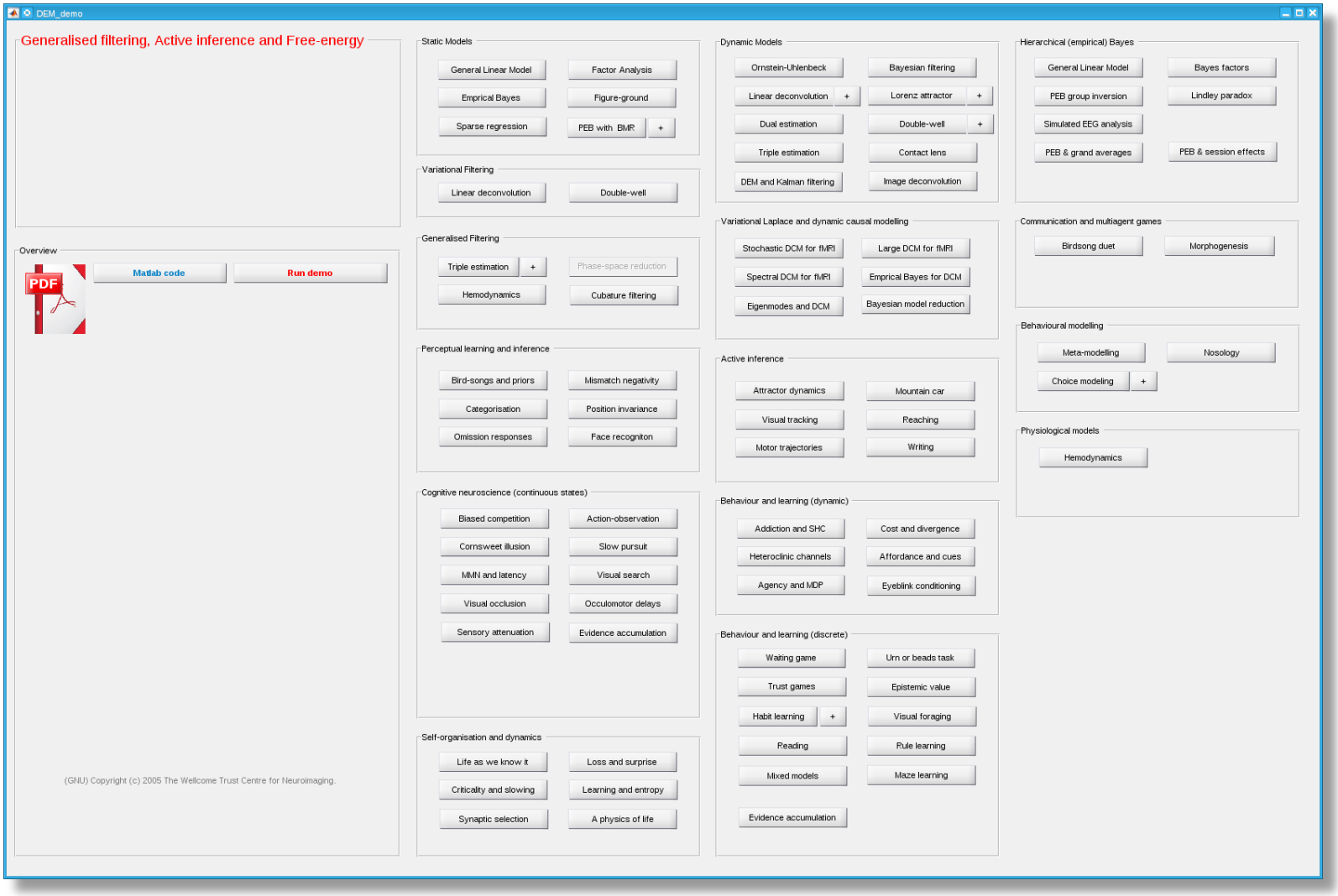
WaveLab and Reproducible Research, J.B. Buckheit and D.L. Donoho. In: Wavelets and Statistics. Springer-Verlag 1995.

Reproducible Research

- Internet: *distribution, collaboration.*
- Freeware: *GNU licences, copyleft.*
- Quantitative Programming Environments: *high-level, fourth generation programming languages (MATLAB, R, Python, Julia, …)*

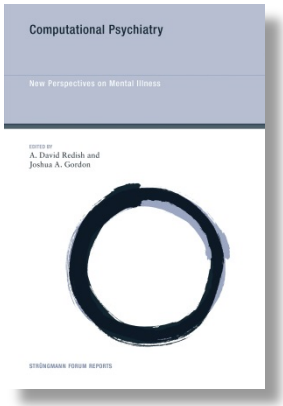
In the future, we can envision that publication in computational sciences will change so that reproducibility is integrated into process. One way to do this would be if journals were fully electronic, and if we adopted hypermedia techniques. Then every computationally-generated figure and every computationally-generated table in an article would become linked to the code and the computational environment that produced the figure. If one were interested in a figure, one would click on it with a mouse, and a new window would instantly appear, containing the code that the author of the article used to create the figure. To reproduce the figure, but perhaps change slightly the settings of the display software (for example, to view a surface from a different 3-d perspective), one would simply edit the code in the window and re-run the code; the figure would be re-computed and re-displayed.

SPM & Reproducible Research



Karl Friston's DEM toolbox

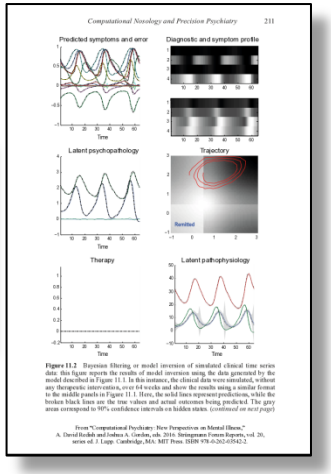
SPM & Reproducible Research

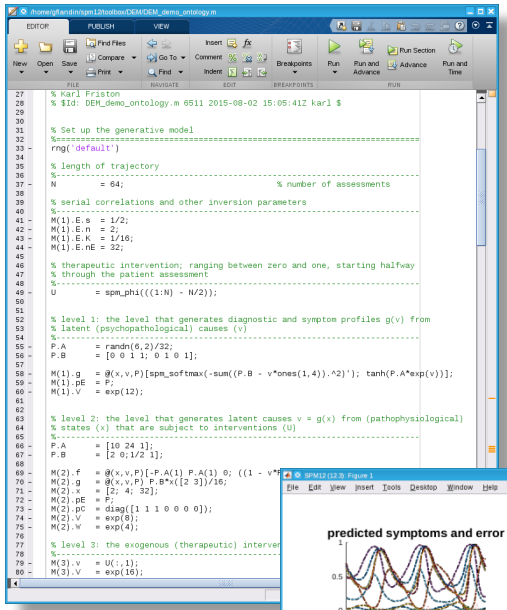


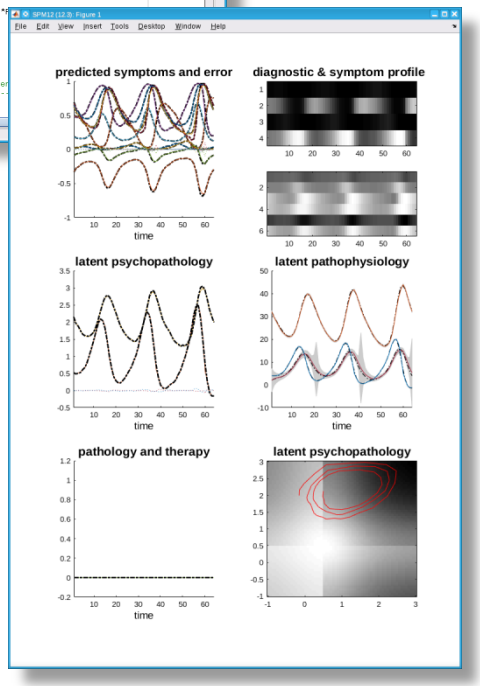
Computational Nosology and Precision Psychiatry

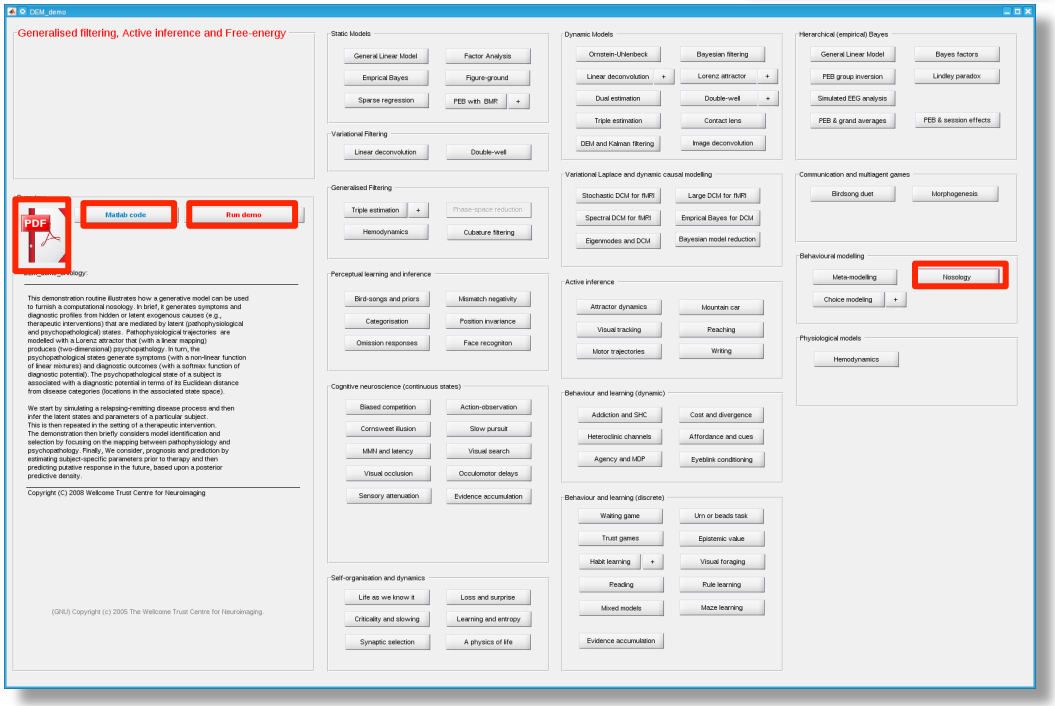
A Proof of Concept

Karl J. Friston







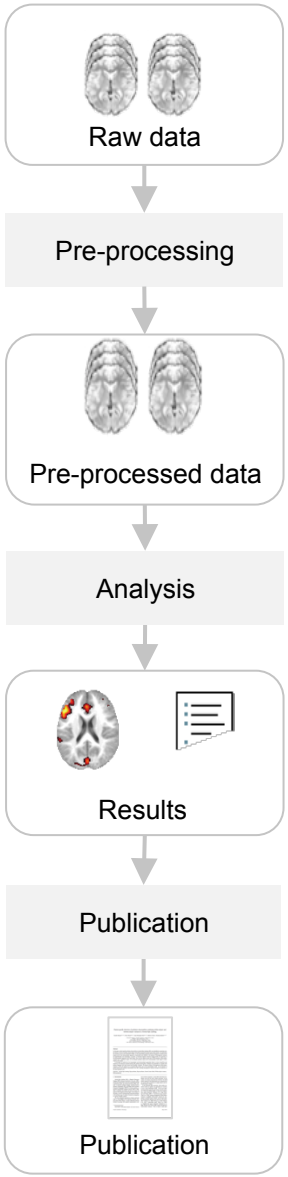


Open Science

- Open Methodology
- Open Source
- Open Data
- Open Access
- Open Peer Review
- Open Educational Resources

https://en.wikipedia.org/wiki/Open_science

Neuroimaging publications



- ✓ Reporting guidelines: COBIDAS
- ✗ Incomplete statistical results
- ✗ Ambiguous/incomplete methods
- ✗ Metadata is not machine readable

Slide: C. Maumet

International Collaborative Effort

- INCF Neuroimaging data sharing Task Force (NIDASH)
  - Representing 13 labs
  - Weekly teleconferences, focused workshops, GitHub
  - Open
- Stanford Center for Reproducible Neuroscience
- ReproNim

http://nidm.nidash.org
http://reproducibility.stanford.edu
http://www.reproducibleimaging.org

Brain Imaging Data Structure

NeuroImaging Data Model

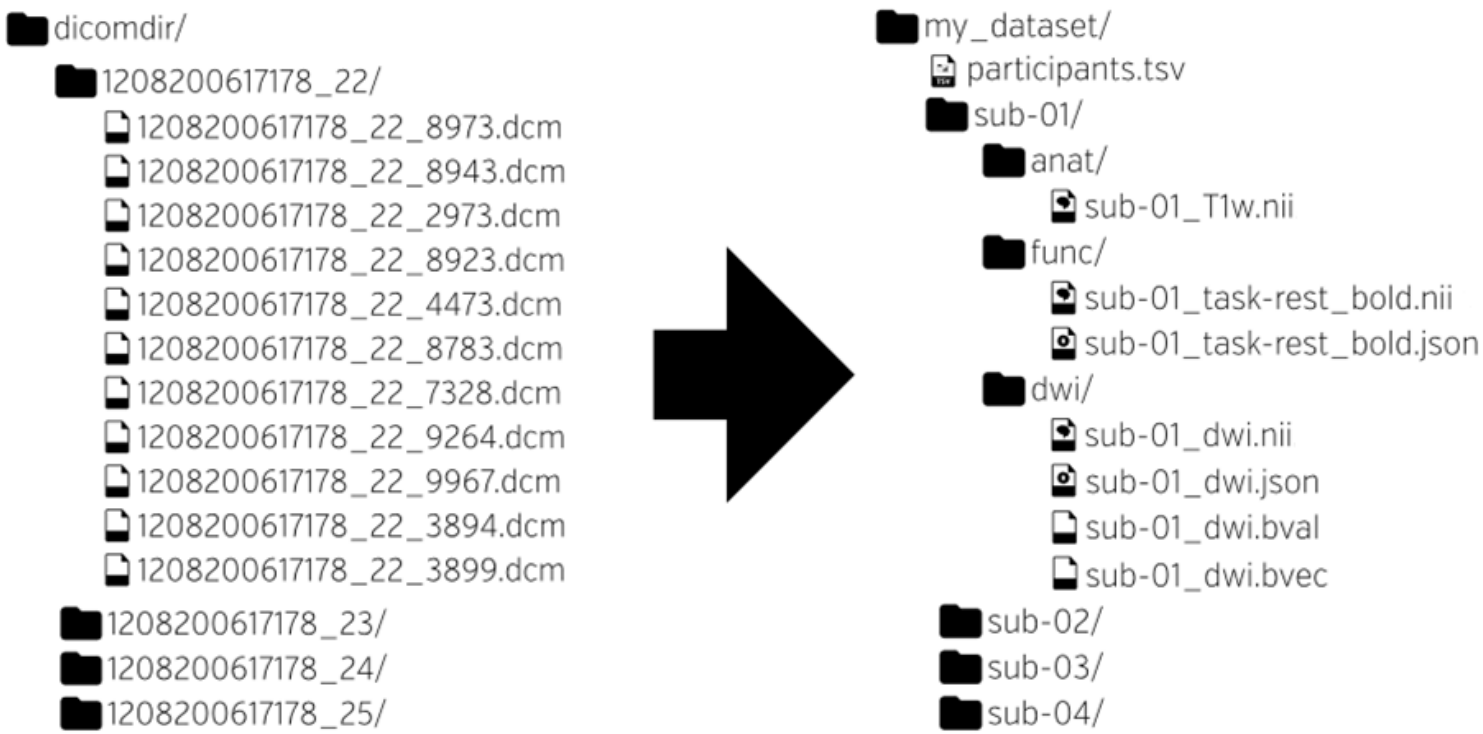
Brain Imaging Data Structure (BIDS)

"A simple and intuitive way to organise and describe your neuroimaging and behavioural data."

Benefits of a common standard:

- Minimised curation
  - Within a lab over time
  - Between labs (collaboration and multi-centre studies)
  - Between public databases (e.g. OpenfMRI)
- Error reduction (automated validation)
- Optimised usage of data analysis software (completely automated analysis workflows)

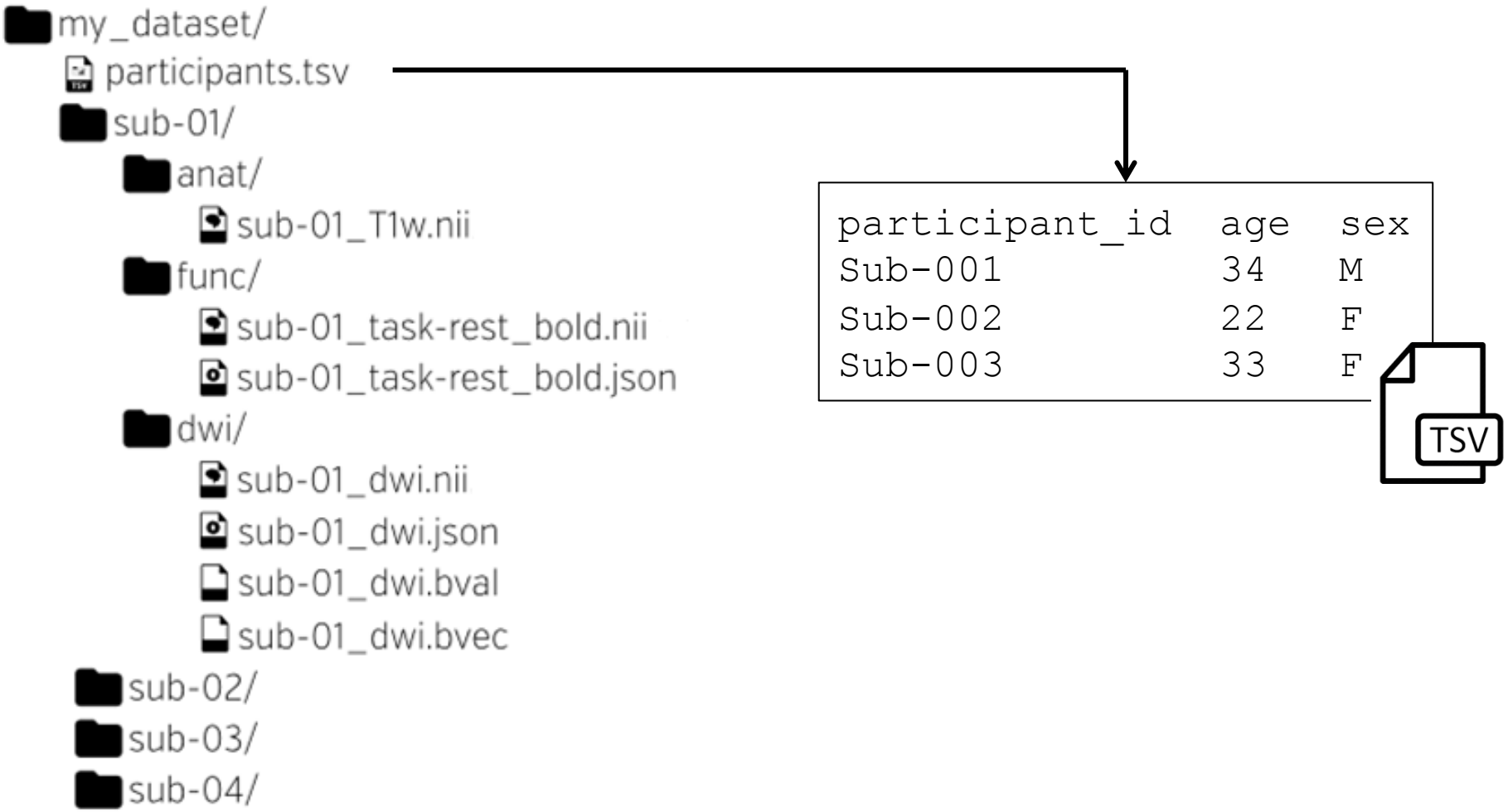
Brain Imaging Data Structure (BIDS)



http://bids.neuroimaging.io/

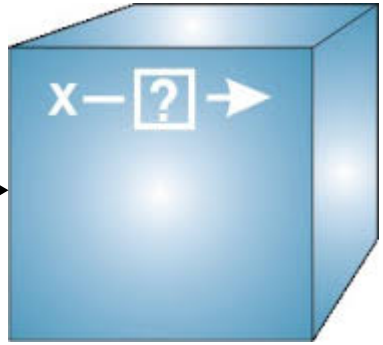
K.J. Gorgolewski et al. The brain imaging data structure, a format for organizing and describing outputs of neuroimaging experiments. *Scientific Data* (2016)

Brain Imaging Data Structure (BIDS)



Brain Imaging Data Structure (BIDS)

- my_dataset/
  - participants.tsv
  - sub-01/
    - anat/
      - sub-01_T1w.nii
    - func/
      - sub-01_task-rest_bold.nii
      - sub-01_task-rest_bold.json
    - dwi/
      - sub-01_dwi.nii
      - sub-01_dwi.json
      - sub-01_dwi.bval
      - sub-01_dwi.bvec
  - sub-02/
  - sub-03/
  - sub-04/



NIfTI

Brain Imaging Data Structure (BIDS)

- my_dataset/
  - participants.tsv
  - sub-01/
    - anat/
      - sub-01_T1w.nii
    - func/
      - sub-01_task-rest_bold.nii
      - sub-01_task-rest_bold.json
    - dwi/
      - sub-01_dwi.nii
      - sub-01_dwi.json
      - sub-01_dwi.bval
      - sub-01_dwi.bvec
  - sub-02/
  - sub-03/
  - sub-04/

```
{
  "RepetitionTime": 2,
  "EchoTime": 0.03,
  "FlipAngle": 78,
  "SliceTiming": [0,1.0325,0.06,…],
  "PhaseEncodingDirection": "j-"
}
```

JSON

BIDS Validator

http://incf.github.io/bids-validator/

Summary

- 40 Files, 18.42kB
- 13 - Subjects
- 1 - Session

Available Tasks

- rhyme judgment

Available Modalities

- bold
- T1w

Your dataset is not a valid BIDS dataset.

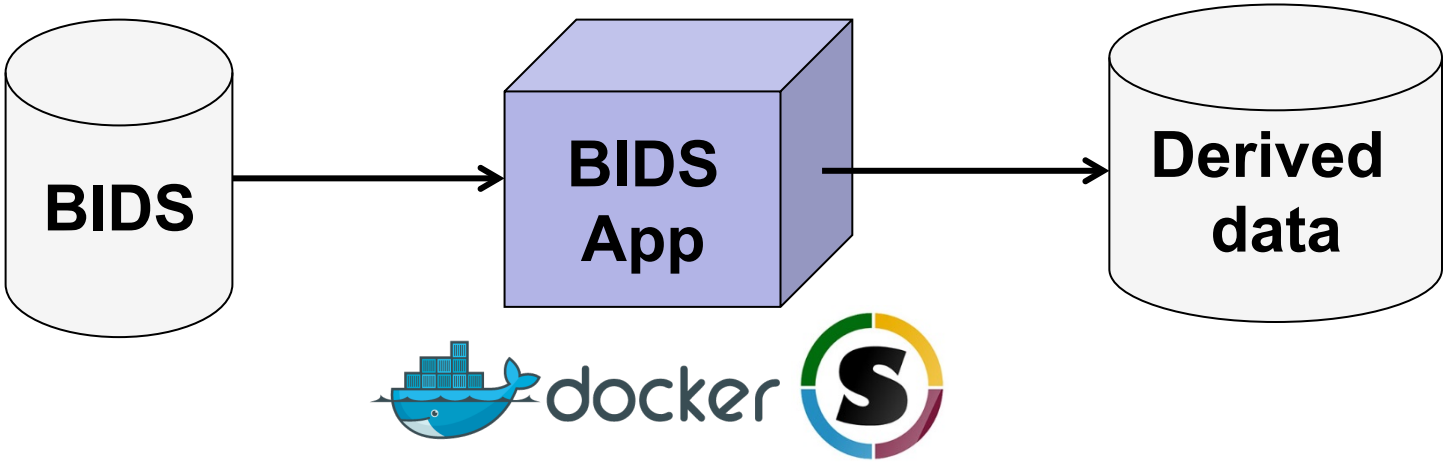
view 1 error in 23 files

view 1 warning in 4 files

BIDS Extensions

- Work in progress:
  - PET / SPECT
  - EEG / MEG
  - Model and hypothesis specifications
  - …

BIDS Apps



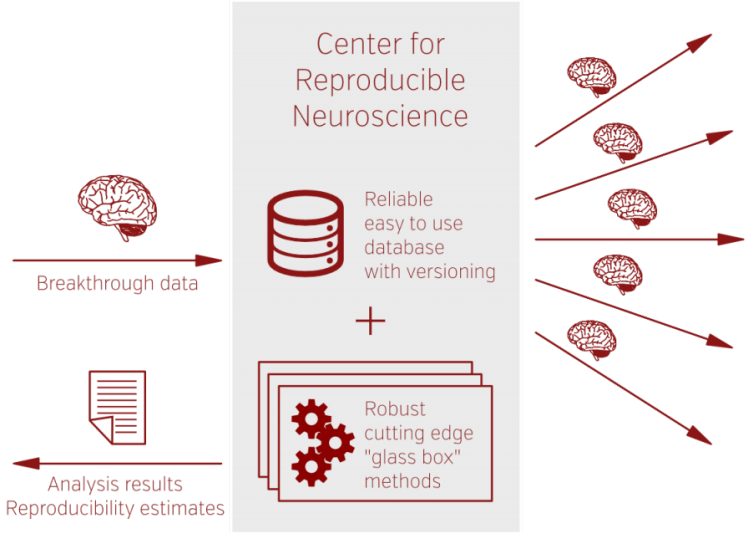

```
docker run … bids/spm /bids /output participant --participant_label 01
docker run … bids/spm /bids /output group
```

http://bids-apps.neuroimaging.io/
https://www.docker.com/
http://singularity.lbl.gov/

K.J. Gorgolewski et al. BIDS Apps: improving ease of use, accessibility, and reproducibility of neuroimaging data analysis methods. *PLOS Computational Biology* (2017)

Available BIDS Apps

bids/example	version 0.0.6	issues 0	build passing
bids/freesurfer	version v6.0.0-2	issues 0	build passing
bids/ndmg	version v0.0.46	issues 0	build passing
bids/BROCCOLI	version v1.0.0	issues 0	build passing
bids/FibreDensityAndCrosssection	version v0.0.1	issues 0	build passing
bids/SPM	version v0.0.5	issues 0	build passing
bids/MRIQC	version 0.0.2	issues 0	build Project not found
bids/QAP	Image not found	issues 0	build passing
bids/CPAC	version v1.0.1a_13	issues 0	build passing
bids/hyperalignment	Image not found	issues 0	build passing
bids/mindboggle	version 0.0.1	issues 2	build failed
bids/MRtrix3_connectome	version latest	issues 0	build passing
bids/rs_signal_extract	version 0.1	issues 0	build passing
bids/aa	version enh_vario...	issues 0	build passing
bids/niak	version latest	issues 3	build passing
bids/oppni	version latest	issues 0	build passing
bids/fmriprep	version 0.2.0	issues 0	build passing
bids/brainiak-srm	version latest	issues 0	build passing
bids/nipypelines	Image not found	issues 0	build passing
bids/HCPPipelines	version v3.17.0-13	issues 0	build passing
bids/MAGeTbrain	Image not found	issues 0	build timedout
bids/tracula	version v6.0.0-2	issues 0	build passing



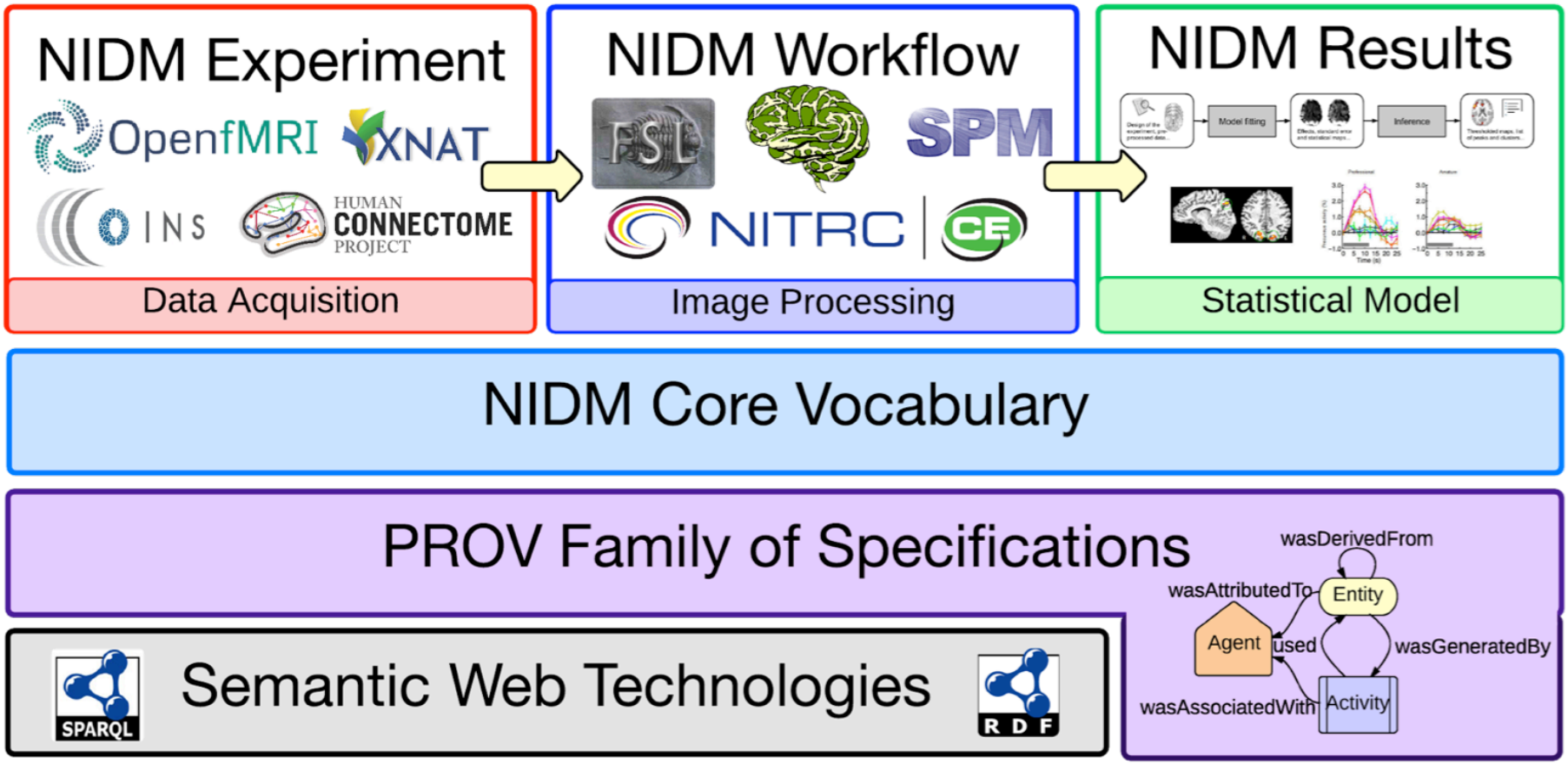
Providing access to state of the art methods while incentivizing data sharing

http://bids-apps.neuroimaging.io/

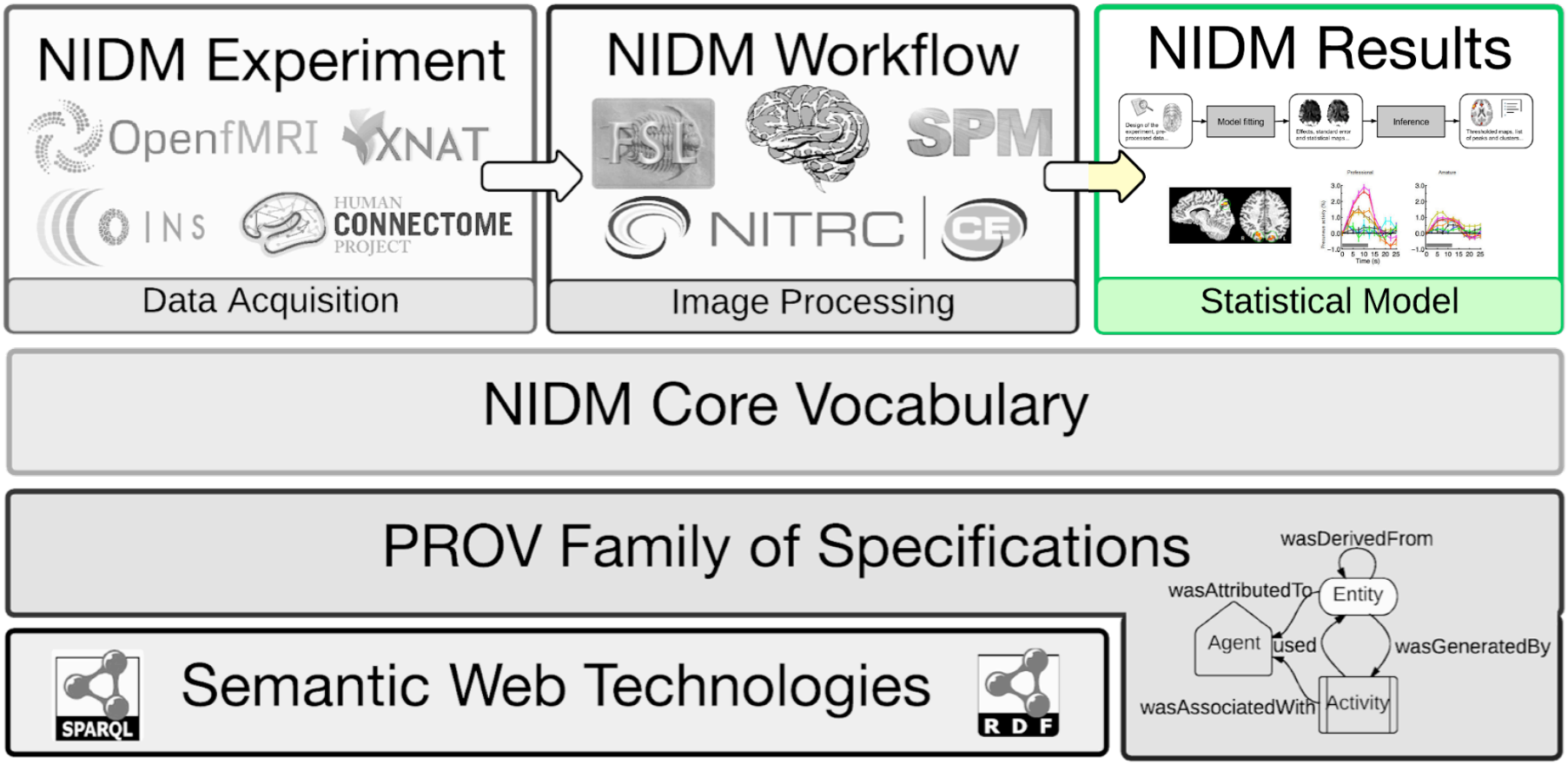
Brain Imaging Data Structure

NeuroImaging Data Model

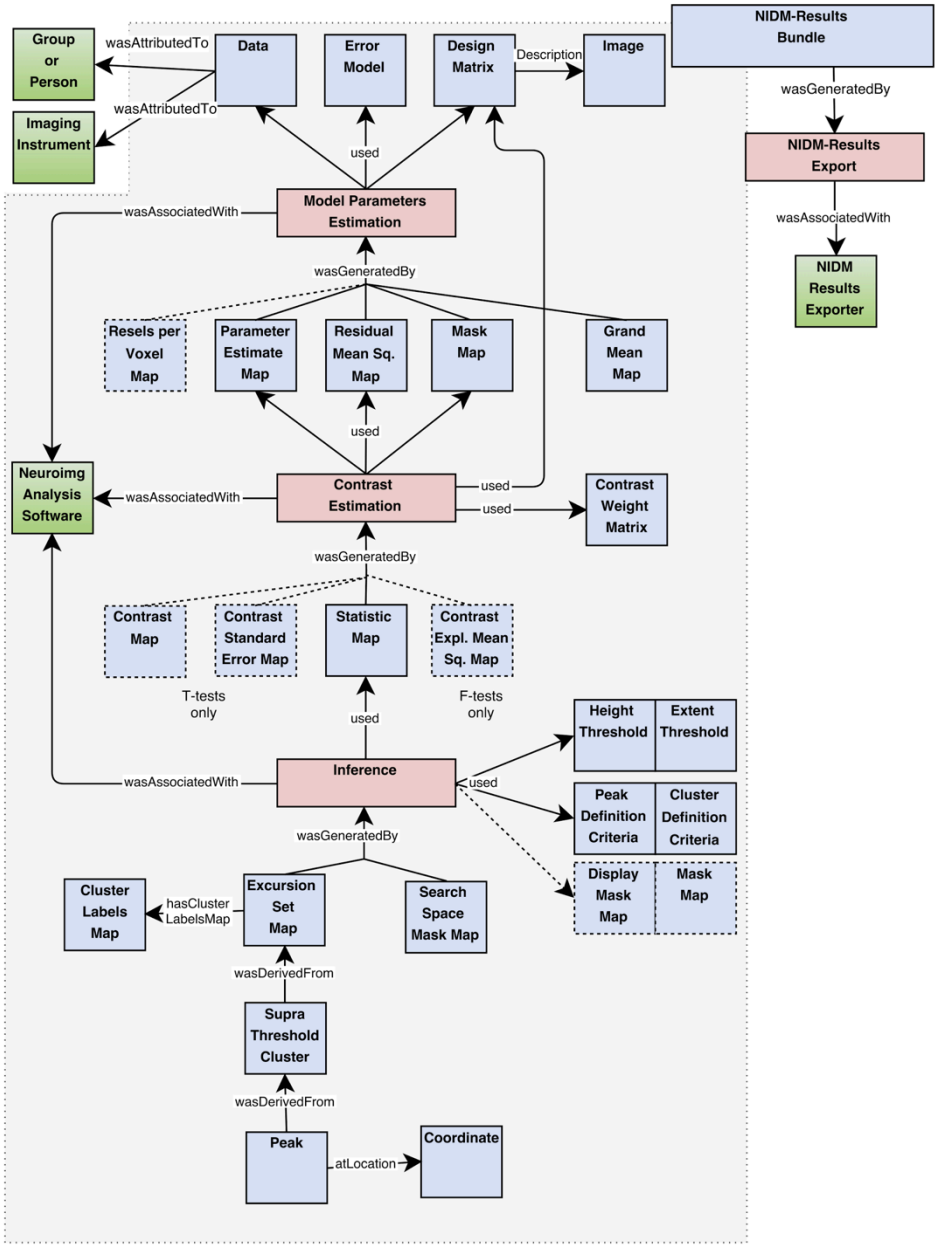
NIDM: a set of specifications to describe neuroimaging data

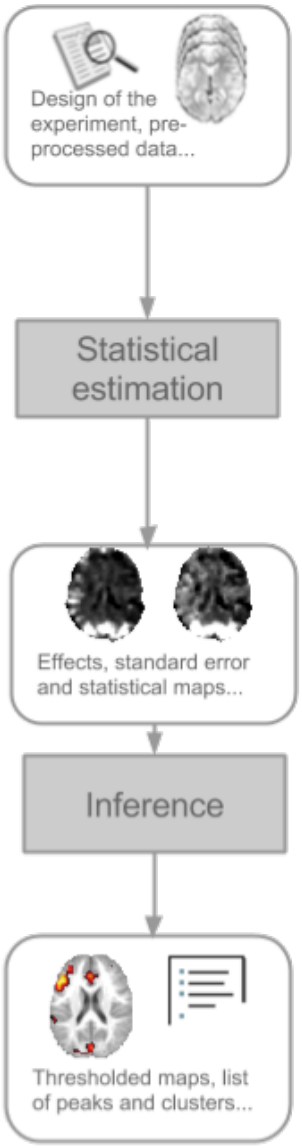


NIDM: a set of specifications to describe neuroimaging data



NIDM-Results





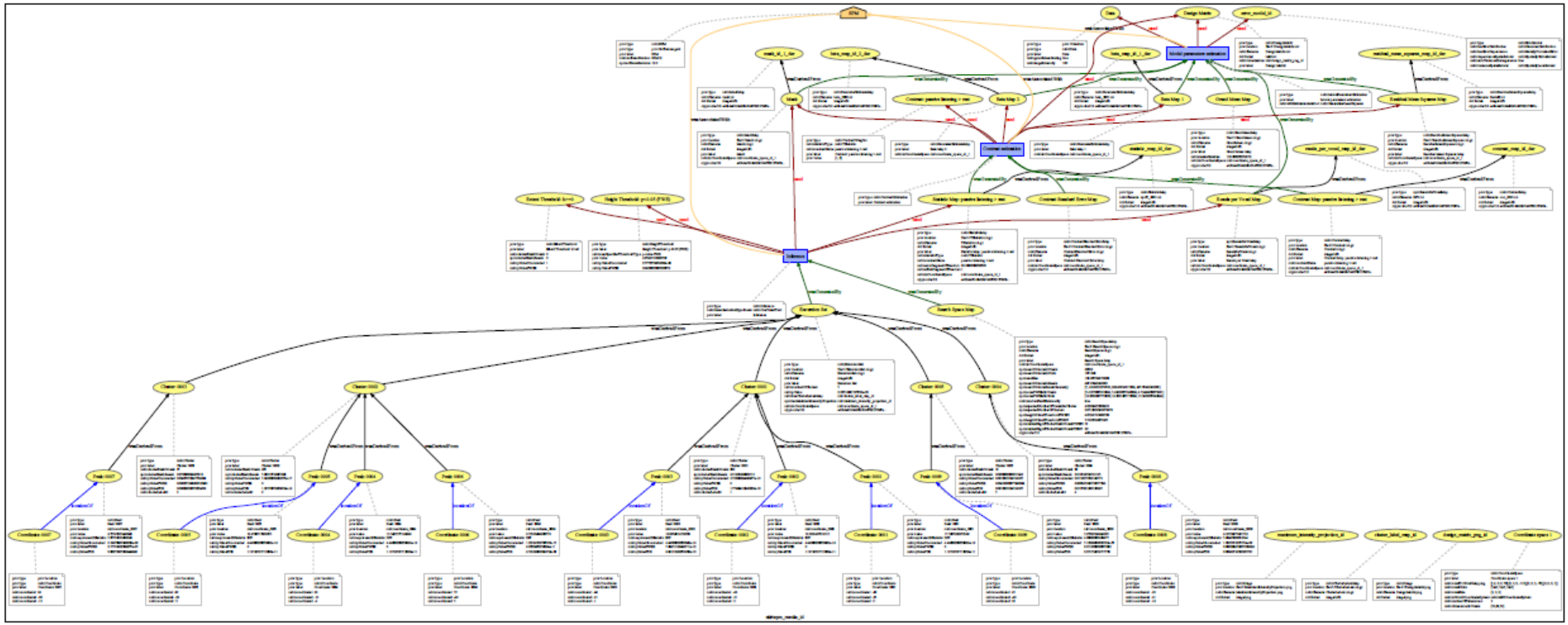
Statistics: *p-values adjusted for search volume*

set-level		cluster-level				peak-level					mm mm mm		
p	c	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	k_E	p_{uncorr}	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	T	$(Z_{\equiv})$	p_{uncorr}			
0.000	12	0.000	0.000	425	0.000	0.000	0.000	17.09	Inf	0.000	57	-22	11
						0.000	0.000	14.42	Inf	0.000	66	-10	-1
						0.000	0.000	10.89	Inf	0.000	69	-19	11
		0.000	0.000	568	0.000	0.000	0.000	15.94	Inf	0.000	-63	-28	14
						0.000	0.000	14.68	Inf	0.000	-48	-34	14
						0.000	0.000	13.23	Inf	0.000	-66	-10	2
		0.000	0.000	31	0.000	0.000	0.003	7.03	6.12	0.000	36	-28	-13
		0.000	0.001	12	0.000	0.000	0.004	6.90	6.03	0.000	54	-1	44
		0.003	0.096	3	0.048	0.002	0.075	6.07	5.44	0.000	-63	-55	-7
		0.000	0.003	10	0.001	0.006	0.207	5.77	5.22	0.000	-33	-31	-19

table shows 3 local maxima more than 8.0mm apart

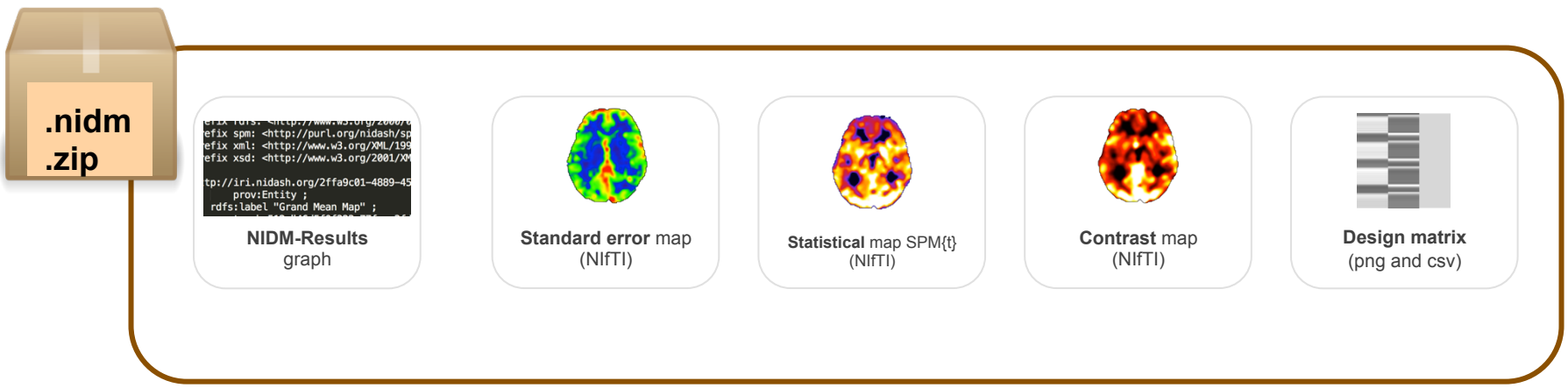
Height threshold: T = 5.25, p = 0.000 (0.050)
Extent threshold: k = 0 voxels
Expected voxels per cluster, <k> = 0.753
Expected number of clusters, <c> = 0.07
FWEp: 5.253, FDRp: 6.320, FWEc: 1, FDRc: 10

Degrees of freedom = [1.0, 73.0]
FWHM = 9.9 9.9 8.6 mm mm mm; 3.3 3.3 2.9 {voxels}
Volume: 1901367 = 70421 voxels = 1995.7 resels
Voxel size: 3.0 3.0 3.0 mm mm mm; (resel = 31.52 voxels)



NIDM-Results

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



C. Maumet et al. Sharing brain mapping statistical results with the neuroimaging data model. *Scientific Data* (2017).

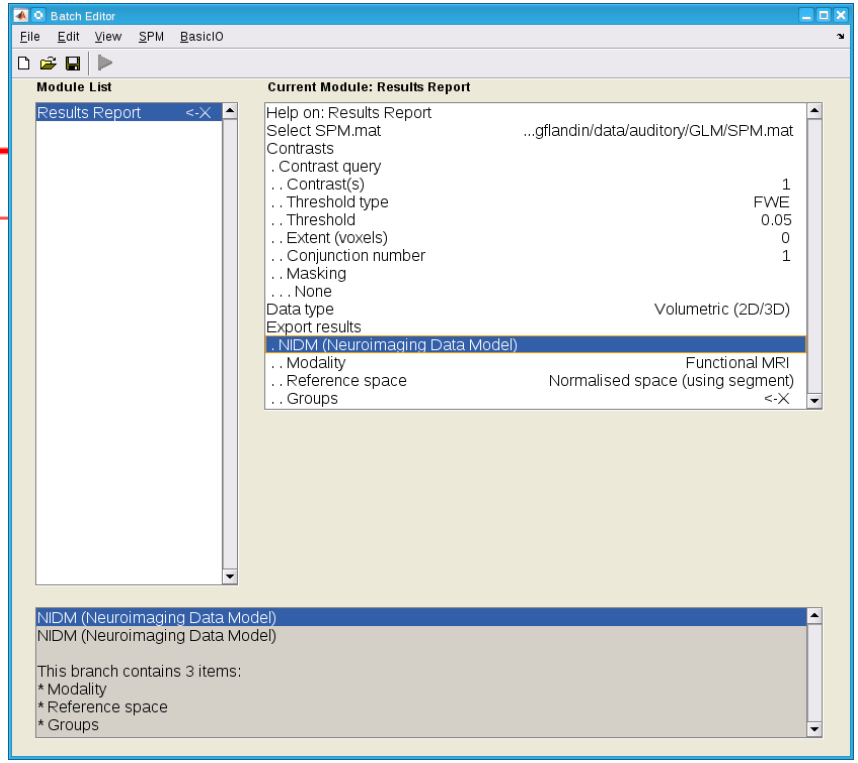
Slide: C. Maumet

SPM export to NIDM-Results

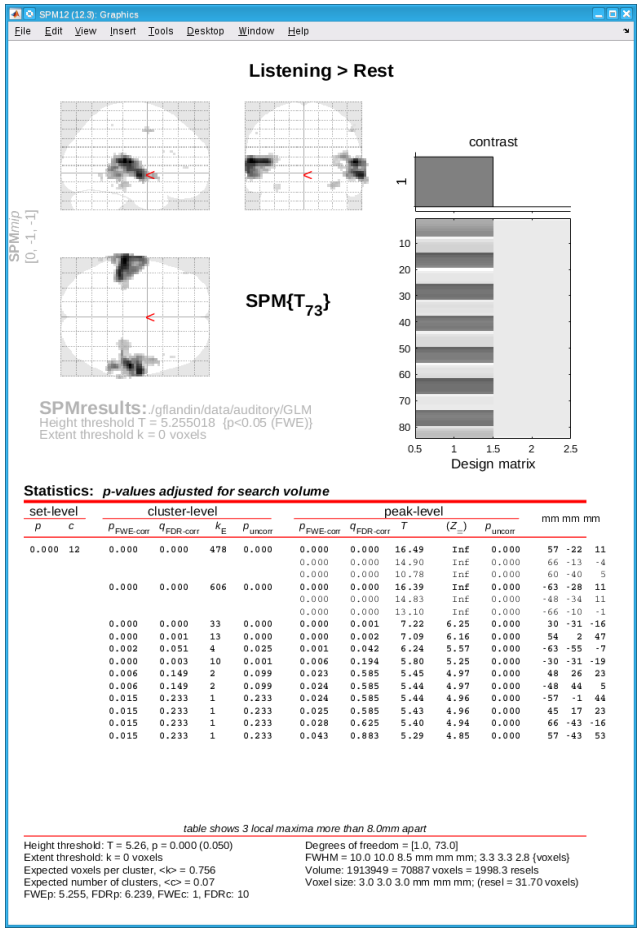
Statistics: ***p-values adjusted for search volume***

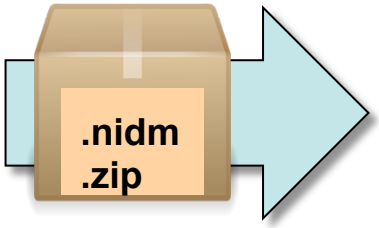
set-level		cluster-level				peak-level				
p	c	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	k_E	p_{uncorr}	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	T	$(Z_{\equiv})$	p_{uncorr}
0.000	12	0.000	0.000	478	0.000	0.000	0.000	16.49	Inf	0.000
						0.000	0.000	14.90	Inf	0.000
						0.000	0.000	10.78	Inf	0.000
		0.000	0.000	606	0.000	0.000	0.000	16.39	Inf	0.000
						0.000	0.000	14.83	Inf	0.000
						0.000	0.000	13.10	Inf	0.000
		0.000	0.000	33	0.000	0.000	0.001	7.22	6.25	0.000
		0.000	0.001	13	0.000	0.000	0.002	7.09	6.16	0.000
		0.002	0.051	4	0.025	0.001	0.042	6.24	5.57	0.000
		0.000	0.003	10	0.001	0.006	0.194	5.80	5.25	0.000
		0.006	0.149	2	0.099	0.023	0.585	5.45	4.97	0.000
		0.006	0.149	2	0.099	0.024	0.585	5.44	4.97	0.000
		0.015	0.233	1	0.233	0.024	0.585	5.44	4.96	0.000
					33	0.025	0.585	5.43	4.96	0.000
					33	0.028	0.625	5.40	4.94	0.000
					33	0.043	0.883	5.29	4.85	0.000

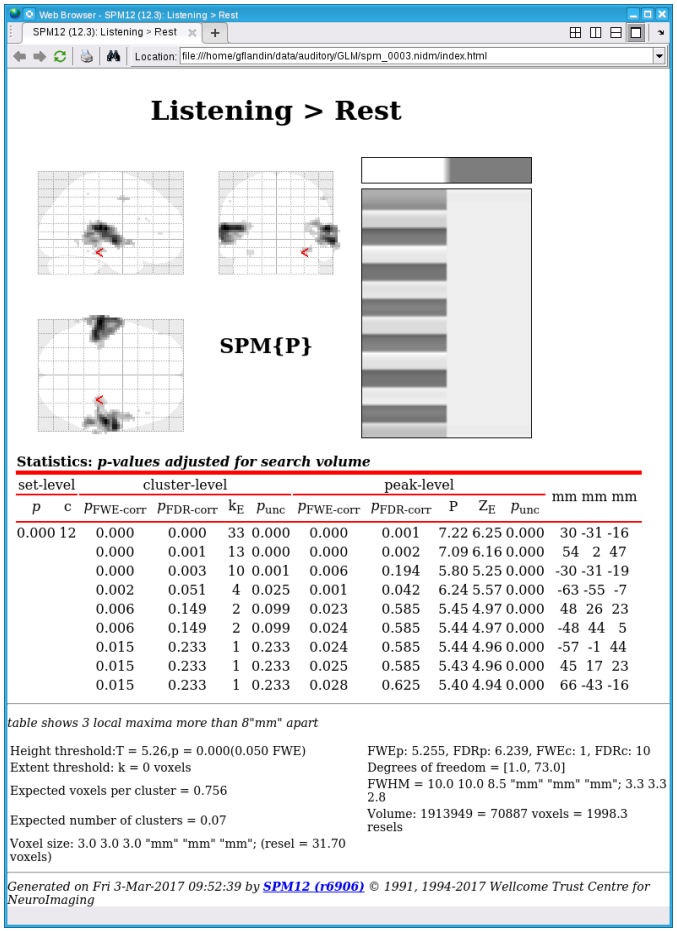
- Print text table
- Extract table data structure
- Export to CSV file
- Export to NIDM-Results ▸
  - Locally
  - Upload to NeuroVault



NIDM-Results Viewer



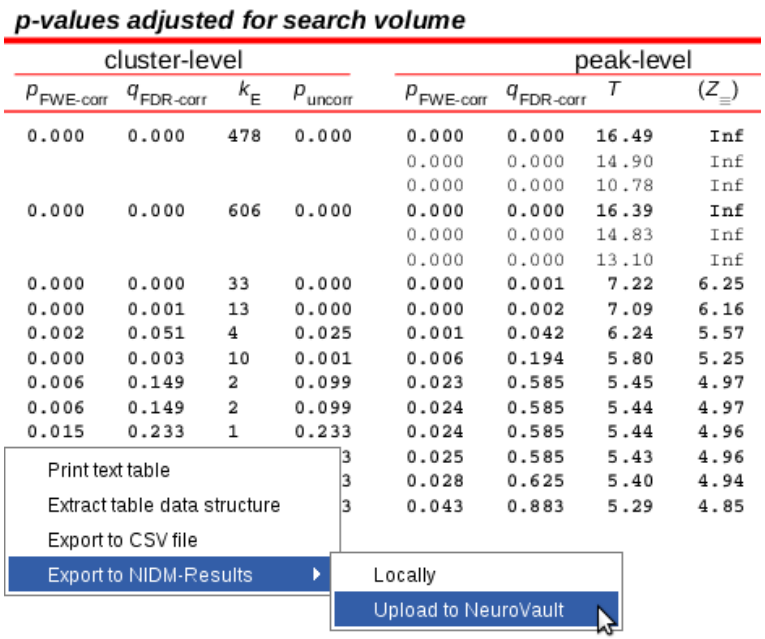




Thomas Maullin-Sapey & Camille Maumet

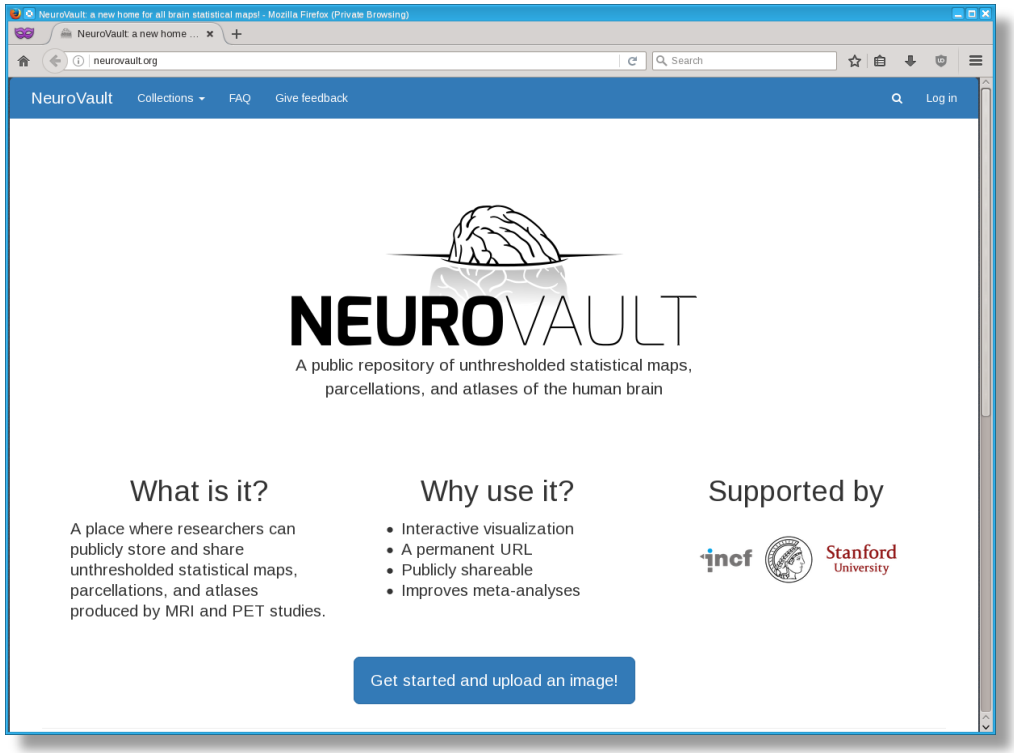
https://github.com/incf-nidash/nidmresults-spmhtml

Upload NIDM-Results to NeuroVault



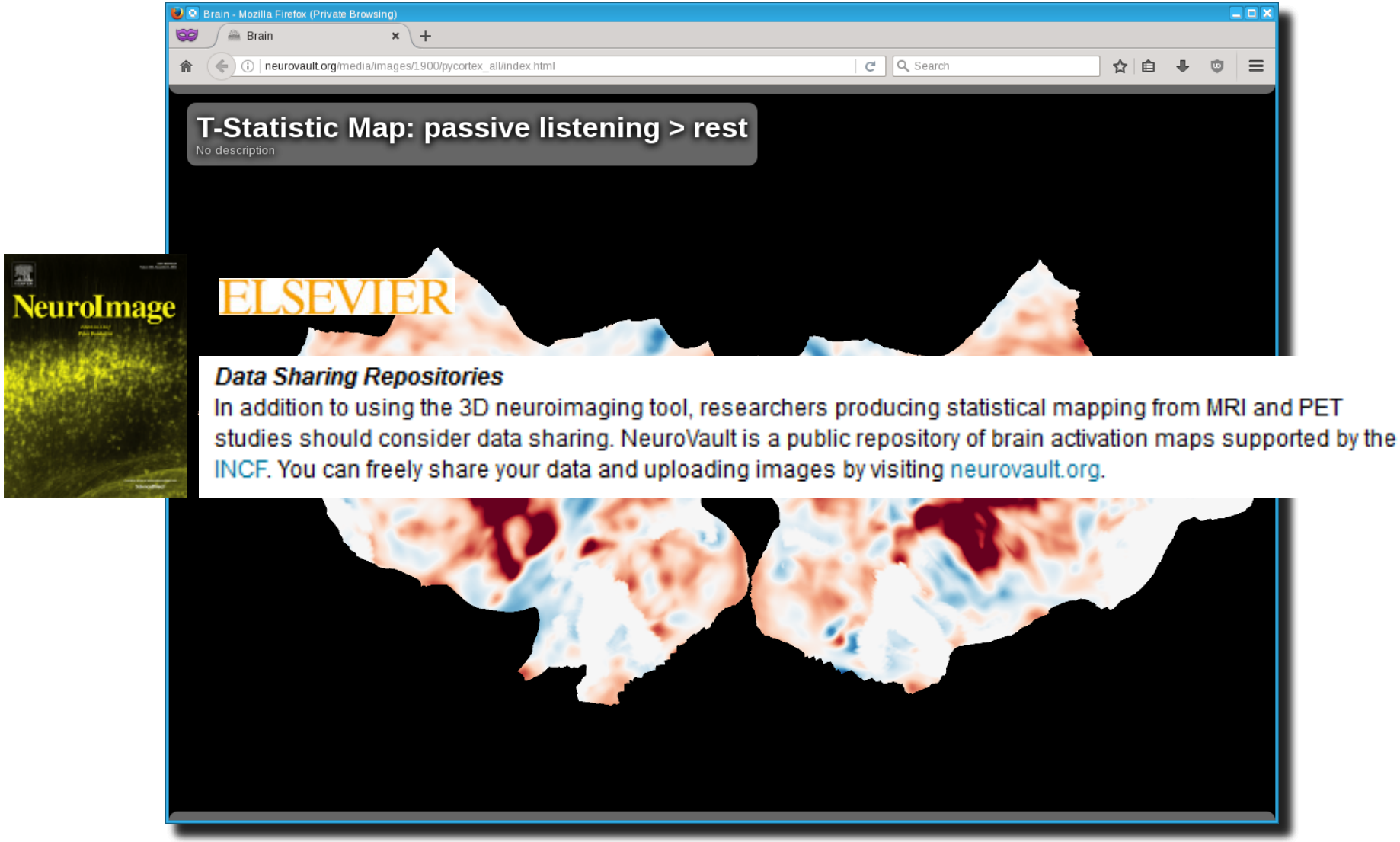
p-values adjusted for search volume

cluster-level				peak-level			
$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	k_E	p_{uncorr}	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	T	$(Z_{=})$
0.000	0.000	478	0.000	0.000	0.000	16.49	Inf
				0.000	0.000	14.90	Inf
				0.000	0.000	10.78	Inf
0.000	0.000	606	0.000	0.000	0.000	16.39	Inf
				0.000	0.000	14.83	Inf
				0.000	0.000	13.10	Inf
0.000	0.000	33	0.000	0.000	0.001	7.22	6.25
0.000	0.001	13	0.000	0.000	0.002	7.09	6.16
0.002	0.051	4	0.025	0.001	0.042	6.24	5.57
0.000	0.003	10	0.001	0.006	0.194	5.80	5.25
0.006	0.149	2	0.099	0.023	0.585	5.45	4.97
0.006	0.149	2	0.099	0.024	0.585	5.44	4.97
0.015	0.233	1	0.233	0.024	0.585	5.44	4.96
			3	0.025	0.585	5.43	4.96
			3	0.028	0.625	5.40	4.94
			3	0.043	0.883	5.29	4.85

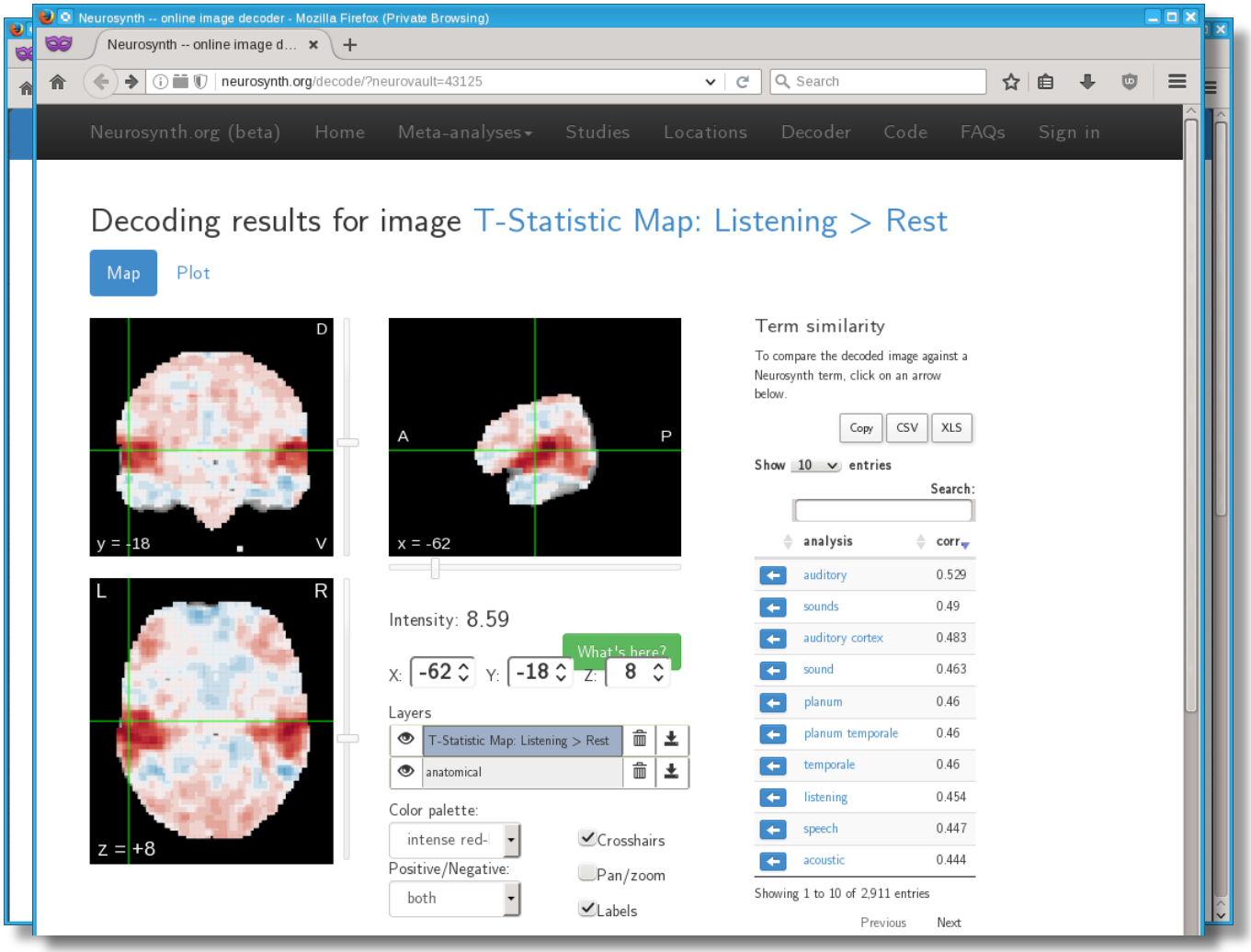


K.J. Gorgolewski et al. NeuroVault.org: a web-based repository for collecting and sharing unthresholded statistical maps of the human brain. *Frontiers in Neuroinformatics* (2015).

Upload NIDM-Results to NeuroVault

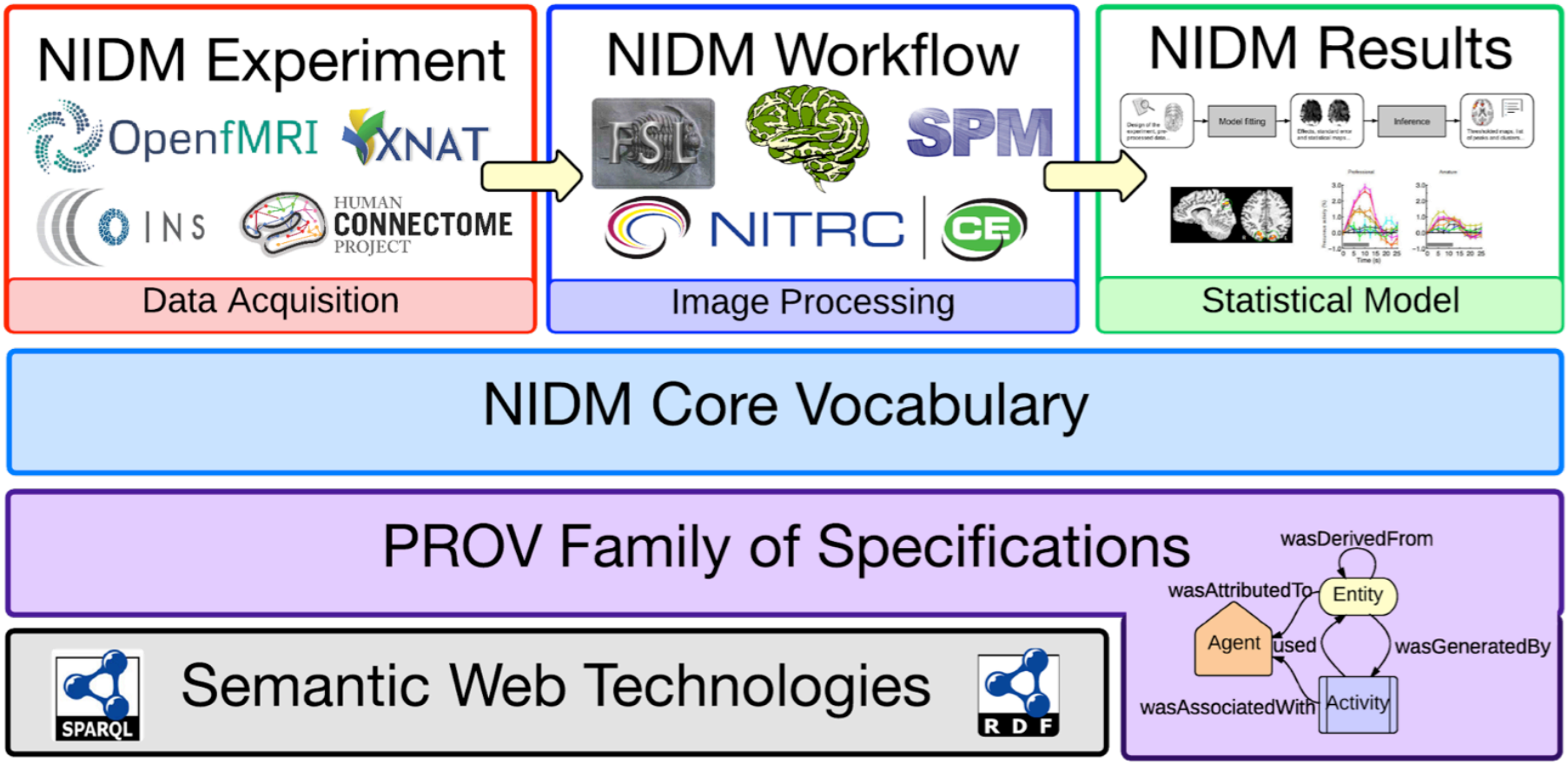


From NeuroVault to Neurosynth

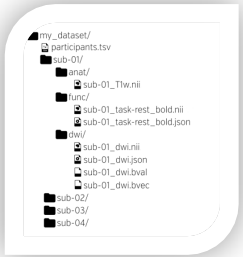


T. Yarkoni et al. Large-scale automated synthesis of human functional neuroimaging data. *Nature Methods* (2011)

NIDM: a set of specifications to describe neuroimaging data



Conclusion

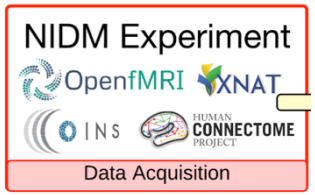


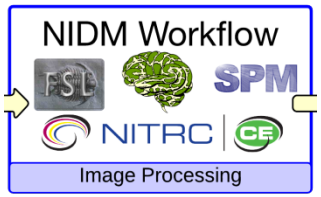
- ❑ BIDS
- ❑ BIDS Apps

openfMRI

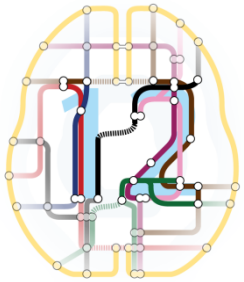
`spm_BIDS.m`

hub.docker.com/r/bids/spm/





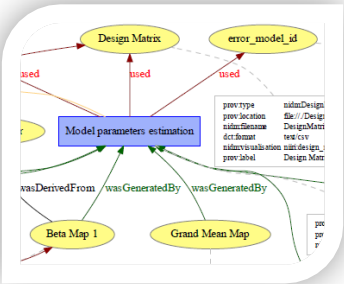
- ❑ NIDM-Experiment
- ❑ NIDM-Workflow



`spm_provenance.m`

`spm_results_nidm.m`

github.com/incf-nidash/nidmresults-spmhtml



- ❑ NIDM-Results
  - Export
  - Viewer
  - Upload to NeuroVault

NeuroVault

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