

Toward an Open Science Ecosystem in Neuroimaging

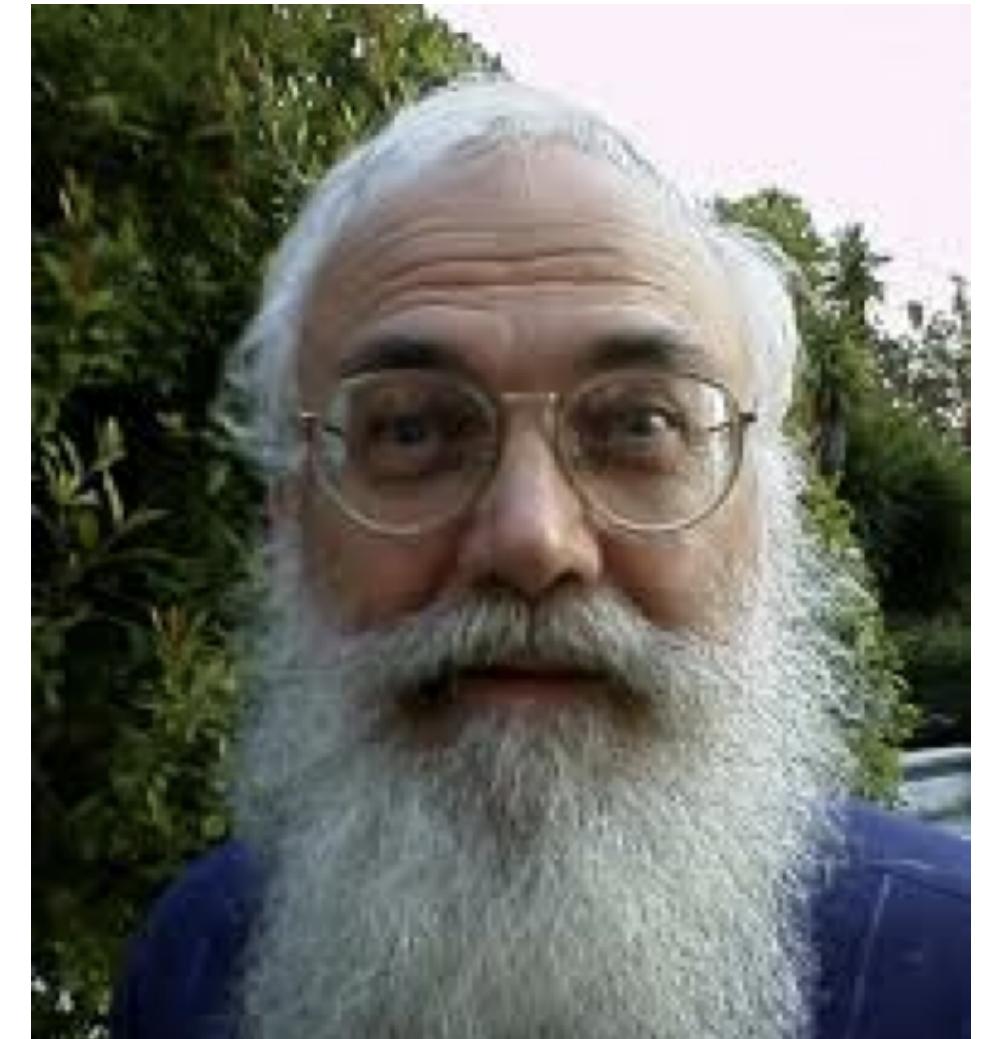
Russ Poldrack
Stanford University

Transparency is essential for reproducibility

		Data	
		Same	Different
Analysis	Same	Reproducible	Replicable
	Different	Robust	Generalisable

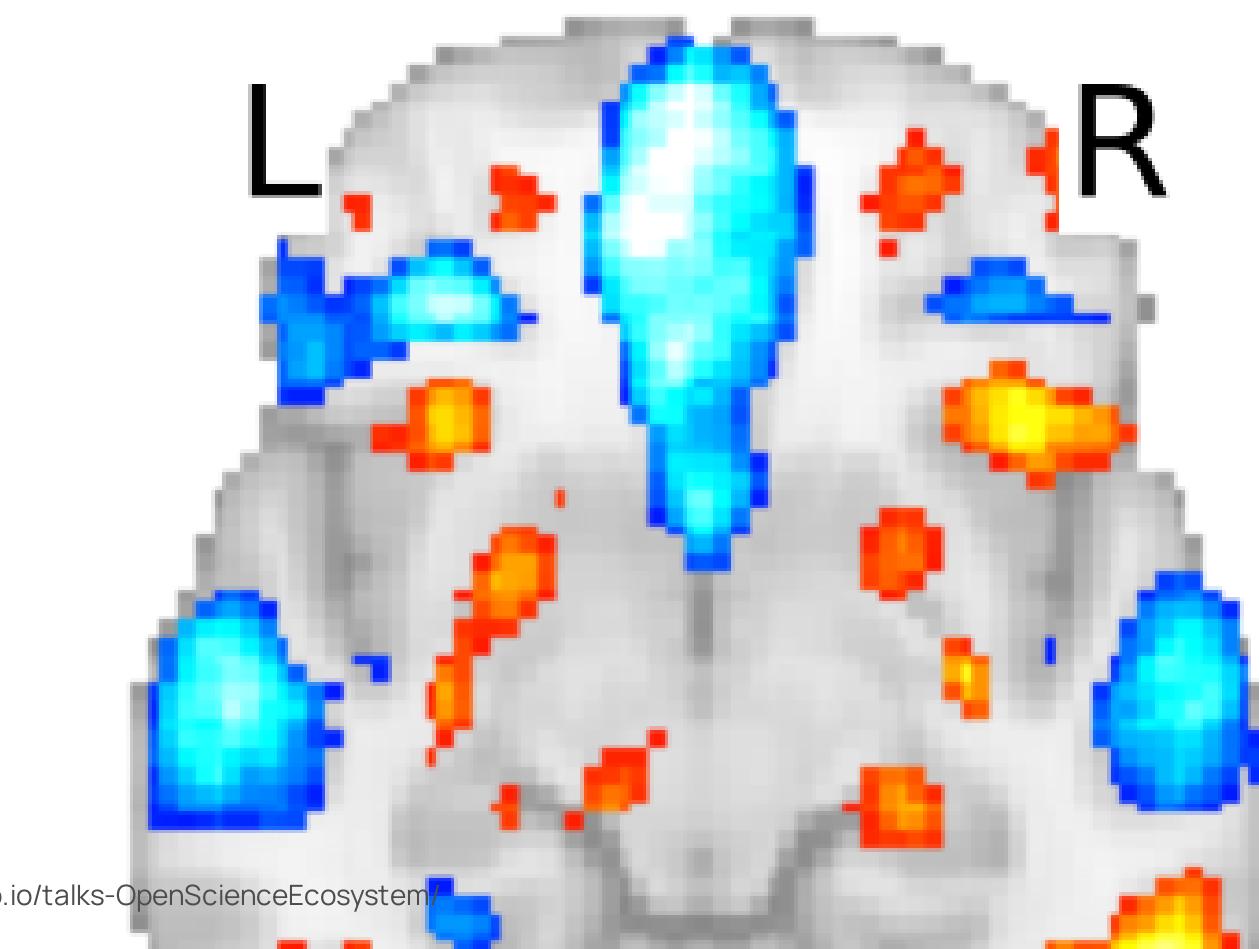
“we can distill Claerbout’s insight into a slogan:

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



Why neuroimaging is a best-case scenario for open science

- Magnetic resonance imaging (MRI) is the primary tool for studying human brain structure and function
- MRI data are digital end-to-end
 - From MRI scanner to automated analysis
 - Usually zero/few manual analysis steps



A false start for fMRI data sharing

The fMRI Data Center
fMRIDC

SEARCH **fMRI**DC Database FOR SUBMIT

[My Account](#) [Request List \(Empty\)](#)

[HOME](#)

[DATABASE](#)

[SUBMISSIONS](#)

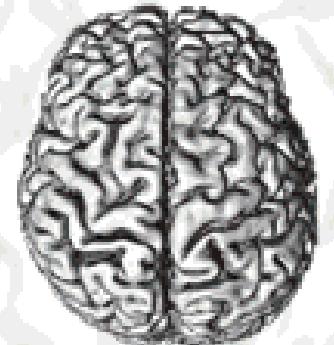
[RESOURCES](#)

[DATA MANAGEMENT TOOL](#)

[HELP](#)

[ABOUT US](#)

[Sitemap](#)



A public repository of peer-reviewed fMRI studies and their underlying data.

Funded By
The National Science Foundation
The W. M. Keck Foundation
The National Institutes of Mental Health
A Sun Center of Excellence for Neuroscience



INFORMATION

[How do I get started?](#)
Answers to questions commonly posed by first-time visitors.

[Q&A about fMRI](#)
A comprehensive list of frequently asked questions about the fMRI

[Available Datasets](#)
A list of datasets currently available.

[Information for Authors](#)

PROJECT STATISTICS

[Registered users:](#) 1912
[Datasets available:](#) 110
[Dataset requests:](#) 1789
[More database statistics...](#)

Updated November 18, 2005

 **Special Collections**
Data from special or rare populations of subjects.

 **Summer Workshops**

[fMRI](#)DC NEWS

[fMRI](#)DC Releases DCSearch (beta)
November 10, 2005 - Now Search the fMRI Data Center archive by anatomical region, Brodmann area, talairach/MNI coordinates, and other fields.

[Michael Gazzaniga Elected to Institute of Medicine](#)
October 24, 2005 - fMRIDC//PolBrackig@sub.iotalks-OpenScienceEcosystem/Honor

A false start for fMRI data sharing

nature
neuroscience

A debate over fMRI data sharing

nature

3 August 2000 Volume 406 Issue no 6795

Whose scans are they, anyway?

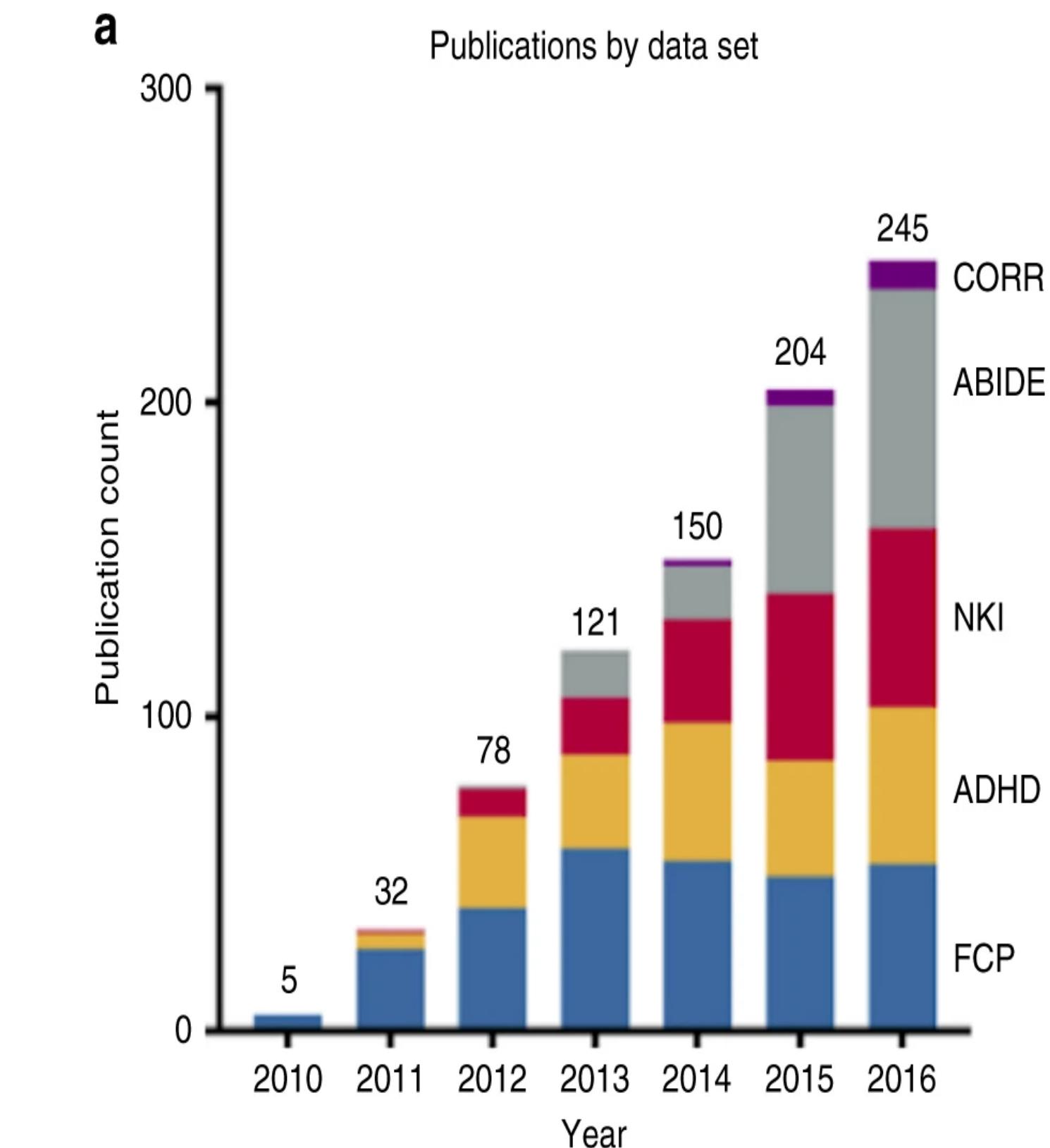
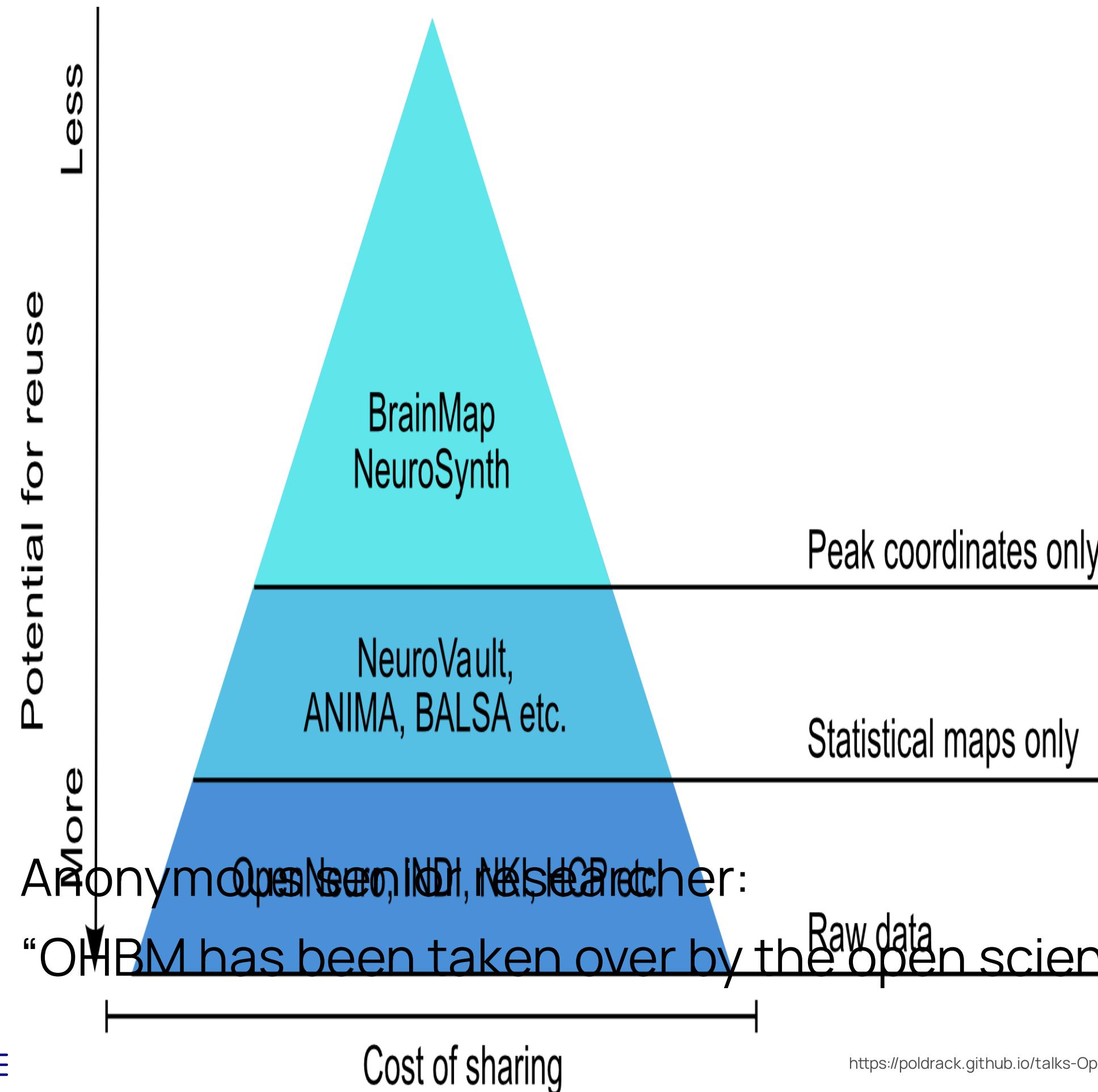
This letter comes from a group of scientists who are publishing papers using fMRI to understand the links between brain and behavior. We are writing in reaction to the recent announcement of the creation of the National fMRI Data Center (www.fmridc.org). In the letter announcing the creation of the center, it was also implied that leading journals in our field may require authors of all fMRI related papers accepted for publication to submit all experimental data pertaining to their paper to the Data Center. ...

2010: The year data sharing broke in neuroimaging

Toward discovery science of human brain function

Bharat B. Biswal^a, Maarten Mennes^b, Xi-Nian Zuo^b, Suril Gohel^a, Clare Kelly^b, Steve M. Smith^c, Christian F. Beckmann^c, Jonathan S. Adelstein^b, Randy L. Buckner^d, Stan Colcombe^e, Anne-Marie Dogonowski^f, Monique Ernst^g, Damien Fair^h, Michelle Hampsonⁱ, Matthew J. Hoptman^j, James S. Hyde^k, Vesa J. Kiviniemi^l, Rolf Kötter^m, Shi-Jiang Liⁿ, Ching-Po Lin^o, Mark J. Lowe^p, Clare Mackay^c, David J. Madden^q, Kristoffer H. Madsen^f, Daniel S. Margulies^r, Helen S. Mayberg^s, Katie McMahon^t, Christopher S. Monk^u, Stewart H. Mostofsky^v, Bonnie J. Nagel^w, James J. Pekar^x, Scott J. Peltier^y, Steven E. Petersen^z, Valentin Riedl^{aa}, Serge A. R. B. Rombouts^{bb}, Bart Rypma^{cc}, Bradley L. Schlaggar^{dd}, Sein Schmidt^{ee}, Rachael D. Seidler^{ff,u}, Greg J. Siegle^{gg}, Christian Sorg^{hh}, Gao-Jun Tengⁱⁱ, Juha Veijola^{jj}, Arno Villringer^{ee,kk}, Martin Walter^{ll}, Lihong Wang^q, Xu-Chu Weng^{mm}, Susan Whitfield-Gabrieliⁿⁿ, Peter Williamson^{oo}, Christian Windischberger^{pp}, Yu-Feng Zang^{qq}, Hong-Ying Zhangⁱⁱ, F. Xavier Castellanos^{b,j}, and Michael P. Milham^{b,1}

Data sharing is becoming the norm in neuroimaging



Milham et al., *Nature Communications*, 2018

An open ecosystem for retrospective data sharing

Breadth

The screenshot shows the Neurosynth.org homepage. At the top, there's a navigation bar with links for Neurosynth.org (beta), Home, Meta-analyses, Studies, Locations, Decoder, Code, FAQs, and Sign in. Below the navigation, the text "neurosynth.org" is displayed in a large, bold font. A subtext explains: "Neurosynth is a platform for large-scale, automated synthesis of functional magnetic resonance imaging (fMRI) data. It takes thousands of published articles reporting the results of fMRI studies, chews on them for a bit, and then spits out images that look like this:" Below this text are three brain maps showing red clusters of activity: a sagittal view at y=0, an axial view at x=0, and a coronal view at z=0. The maps are labeled with anatomical axes (D, V, A/P, L/R). At the bottom left, it says "An automated meta-analysis of 790 studies of emotion". To the right of the Neurosynth logo is the NeuroVault logo, which features a stylized brain icon above the word "NEUROVAULT".

<https://poldrack.github.io/talks-OpenScienceEcosystem/>

- Neurosynth.org: Open database of published neuroimaging coordinates
- Neurovault.org: Open archive for neuroimaging results
- OpenNeuro.org: Open

Maximally open sharing

- Data shared under maximally permissive data use agreements:
 - Neurosynth: Open Data Commons Open Database License v1.0
 - Neurovault: CC0
 - OpenNeuro: CC0
- All data available programmatically via web API



- CC0 enables scientists, educators, artists and other creators and owners of copyright- or database-protected content to waive those interests in their works and thereby place them as

Neurosynth: Sharing activation coordinates

- Brain activity is reported in a (somewhat) standardized coordinate system

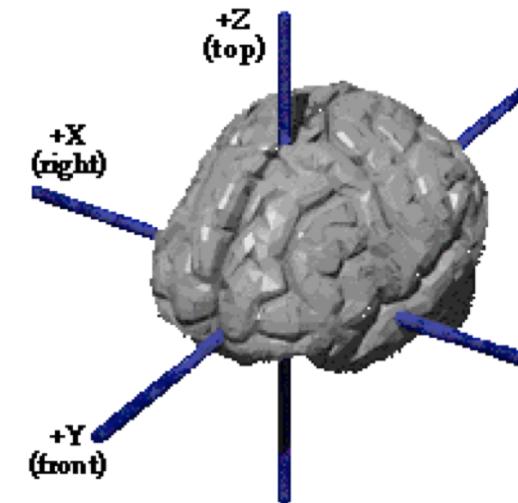


Table 1
Regions that showed a condition × time interaction in the ANOVA analysis

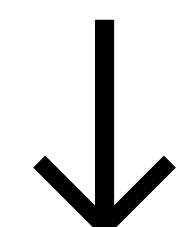
No.	Region	Hemisphere	BA	x	y	z	mm ³
1	Middle/superior temporal gyrus	L	21/22/37	-52	-54	9	13257
2	Inferior frontal gyrus	L	45/46/9	-49	26	6	2781
3	Posterior cerebellum	L		-19	-79	-38	2214
4	Dorsomedial PFC	L	9/8	-11	42	47	3051
5	Left anterior PFC	L	10	-37	49	15	2025
6	Inferior parietal cortex	L	40/7	-42	-58	47	3132
7	Dorsal premotor cortex	L	6	-43	0	50	1485
8	Lingual gyrus	L	17	-10	-95	-2	378
9	Middle /superior temporal gyrus	R	21/22/37	52	-40	5	16470
10	Inferior frontal gyrus	R	45/46	51	28	6	2241
11	Posterior cerebellum	R		23	-78	-34	2808
12	Dorsomedial PFC	R		5	53	29	405

Creating meta-analytic maps

- Automated Coordinate Extraction
 - Automatically extracts activation tables from fMRI papers for 17 journals
 - Current database has 14,371 papers (with full text)
 - 84% sensitivity, 97% specificity

Yarkoni et al. 2011 *Nature Methods* (SumsDB)
against manual database

X	Y	Z
12	57	-6
33	21	15
24	-6	51
28	10	18



working memory

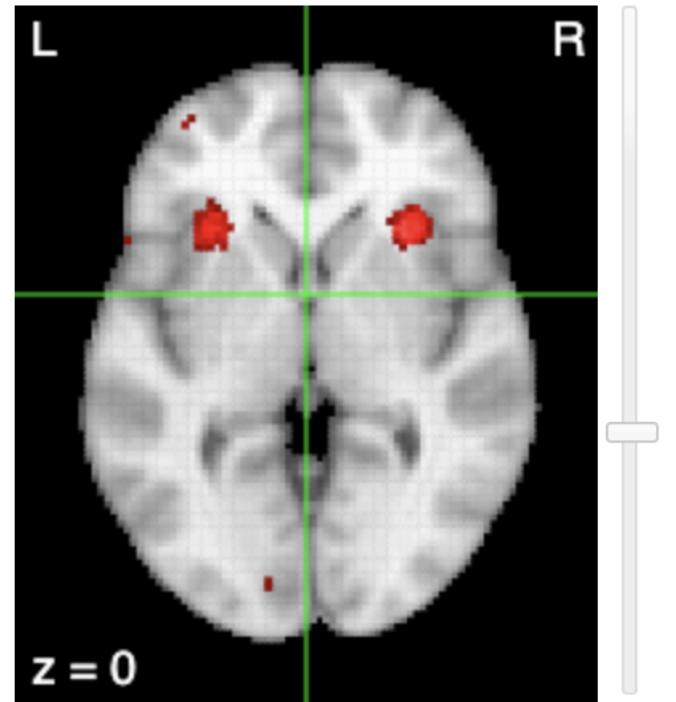
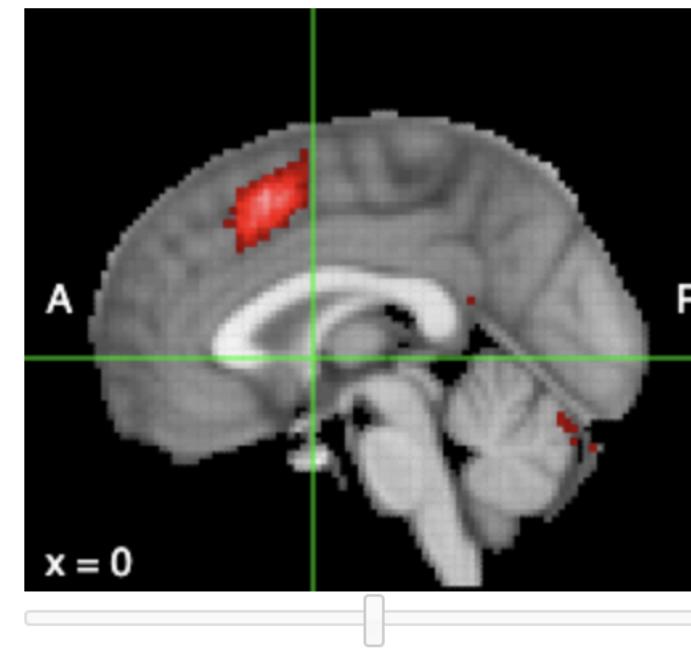
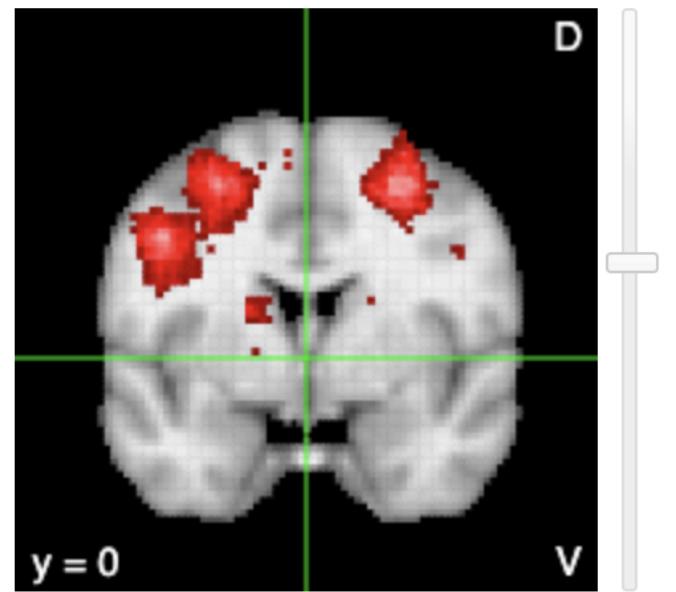
An automated meta-analysis of 1091 studies

Search for another term:

Maps

Studies

FAQs



z-score: 0 What's here?
x: 0 Y: 0 Z: 0

Layers

working memory: association test		
working memory: uniformity test		
anatomical		

Color palette:

red ▼

Crosshairs

Positive/Negative:

positive ▼

Pan/zoom

Labels

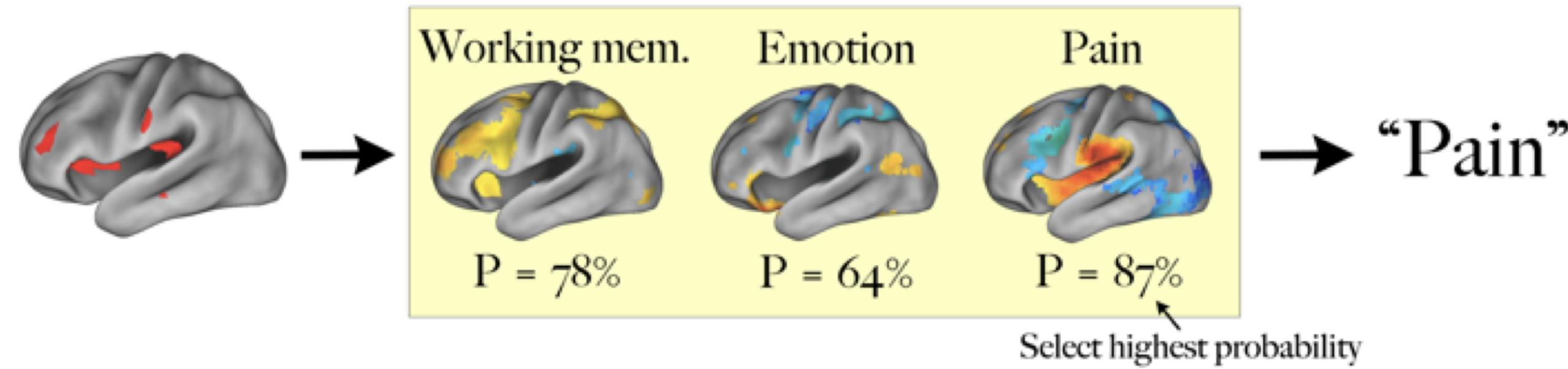
Thresholds:

0 0

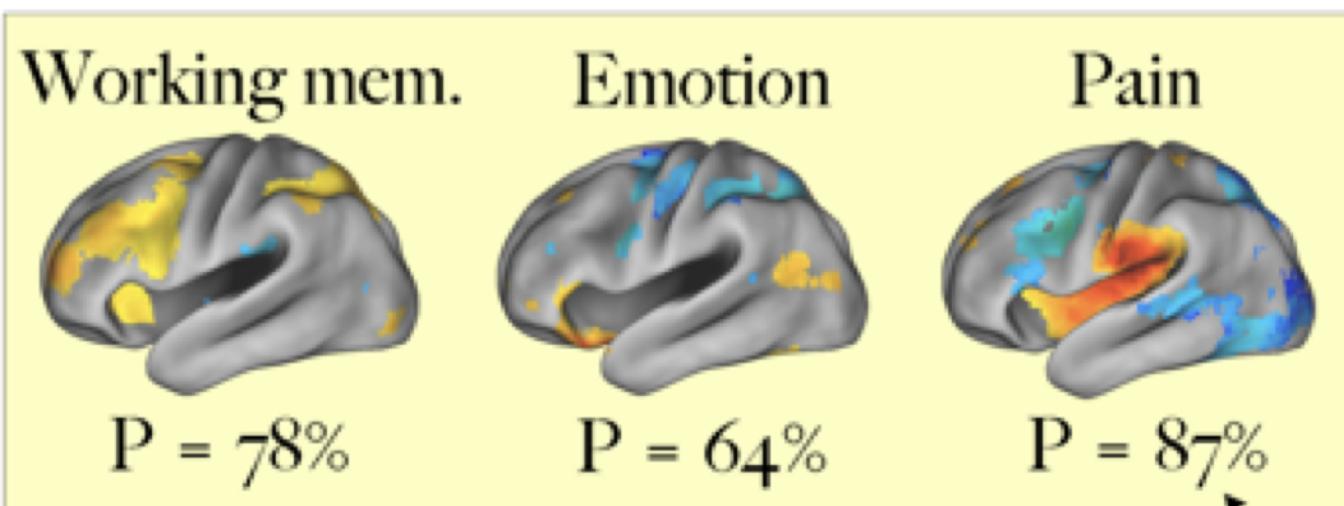
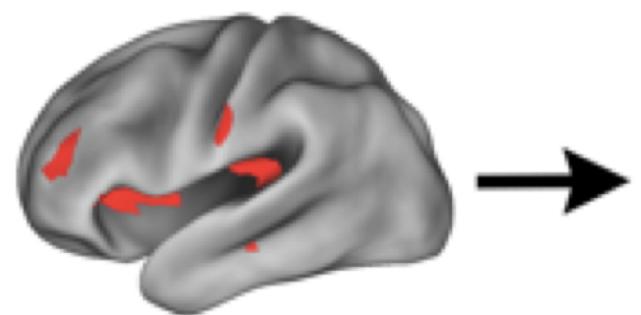
Opacity:

1

Classification

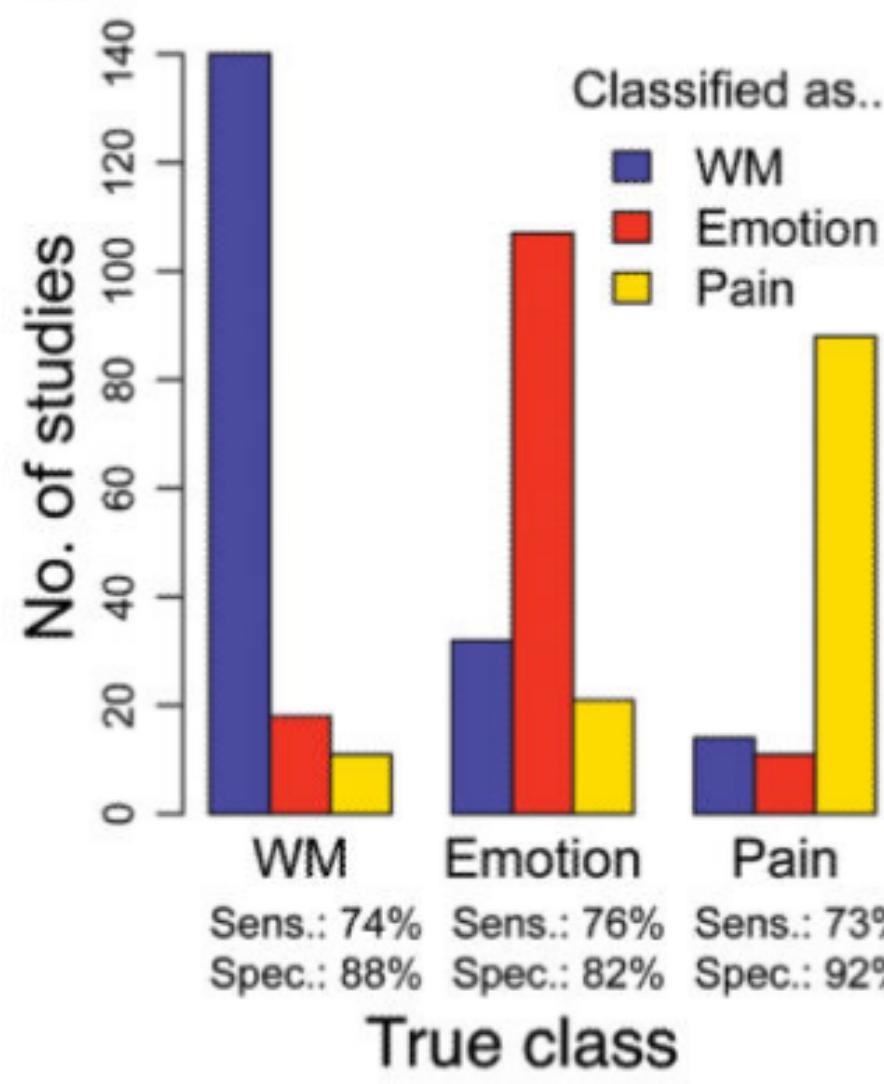


Classification

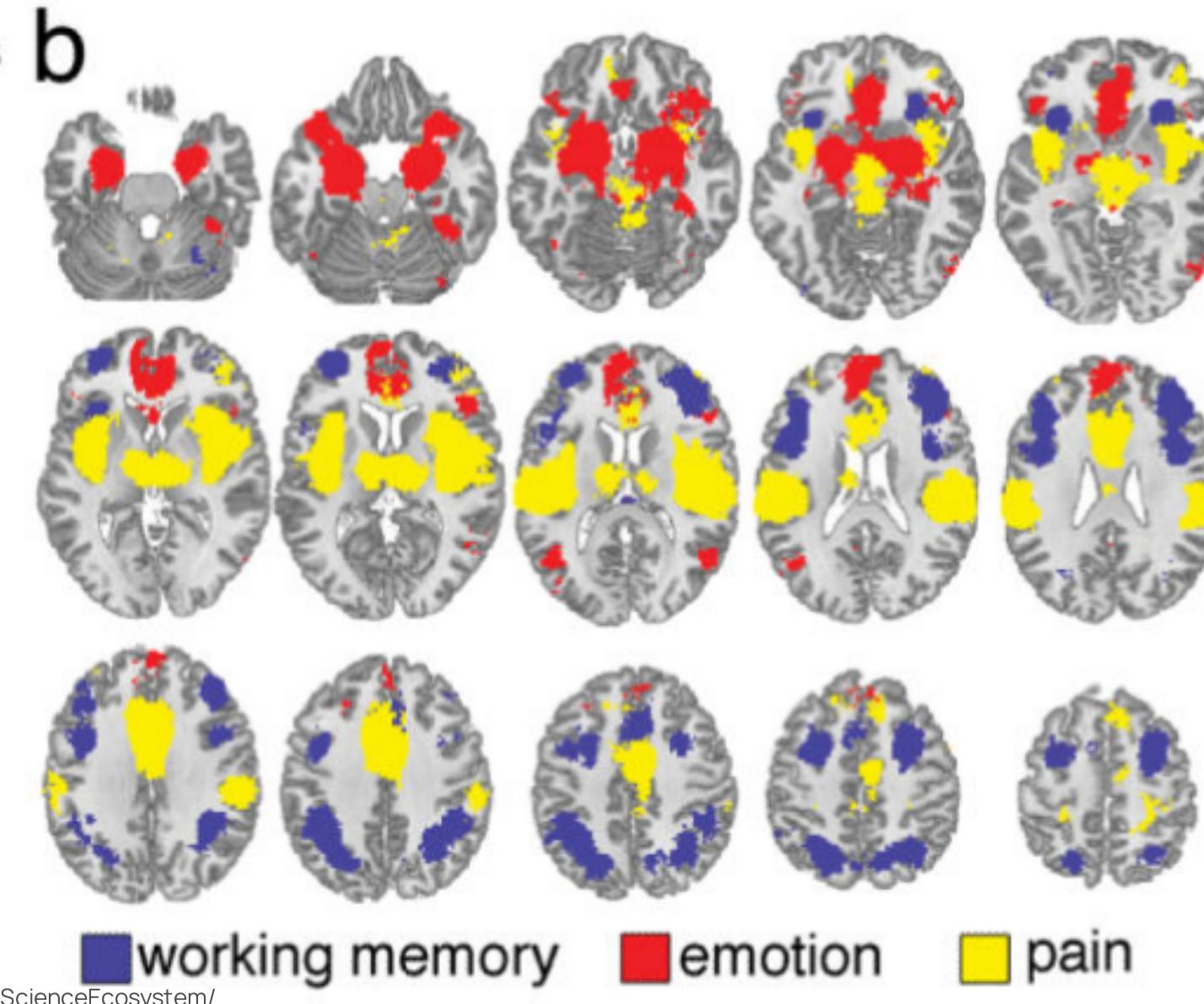
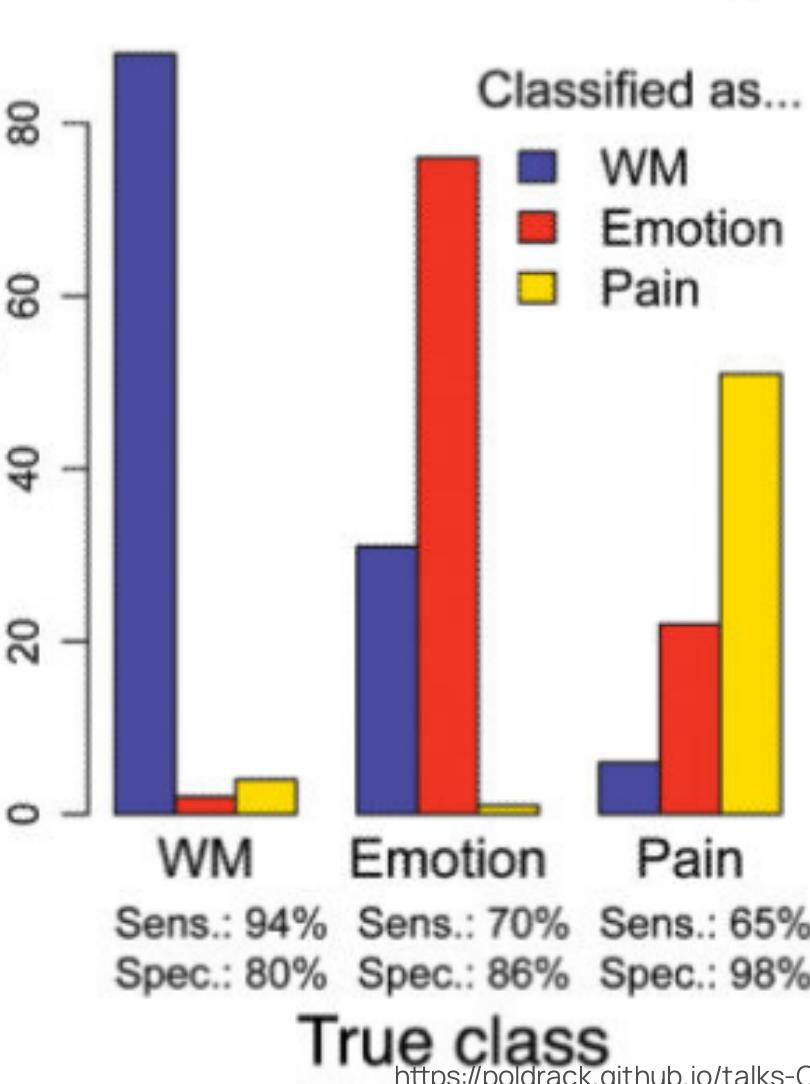


→ “Pain”

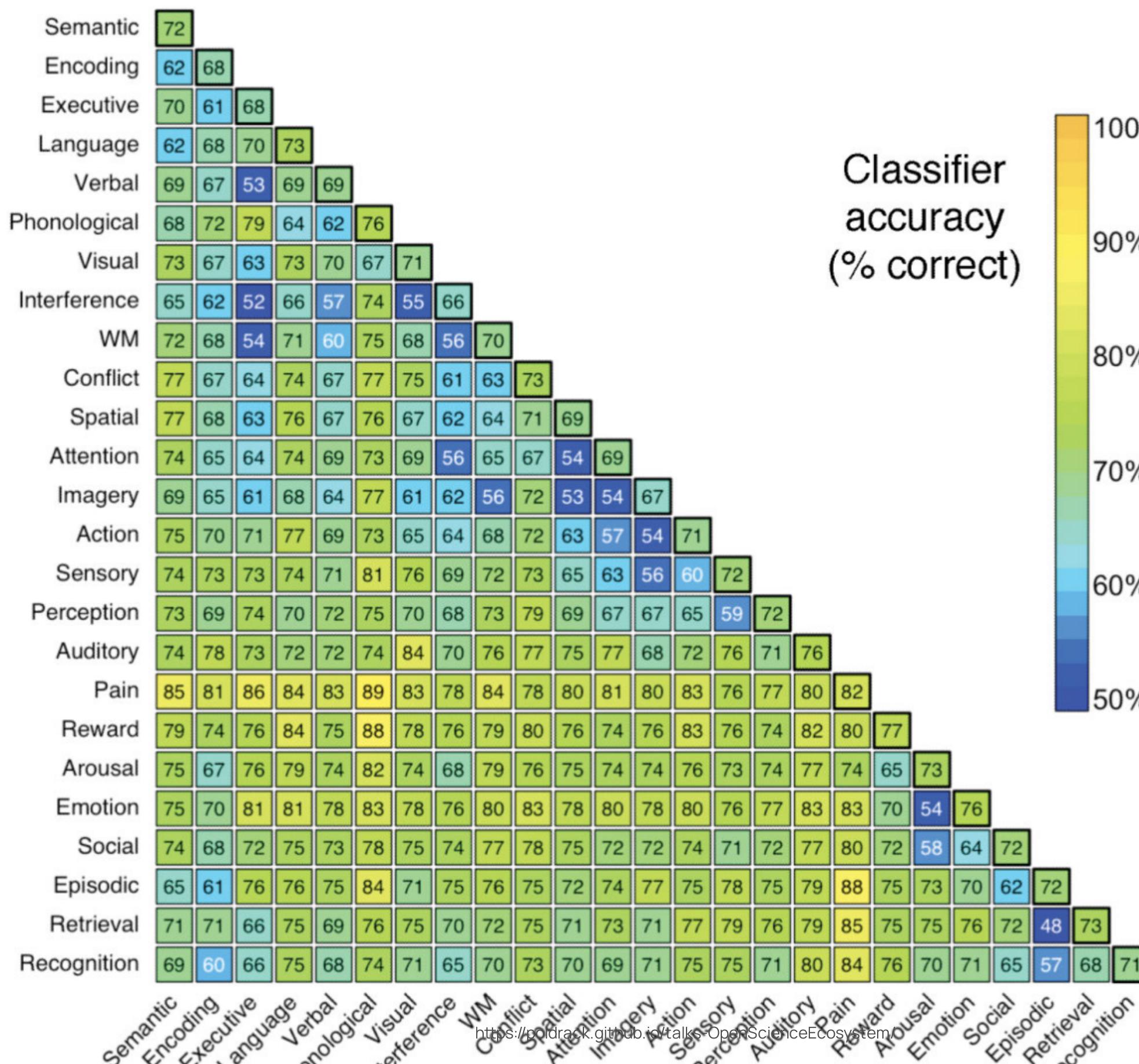
a Classification of new studies



b Classification of new subjects



Decoding brain activity patterns using Neurosynth

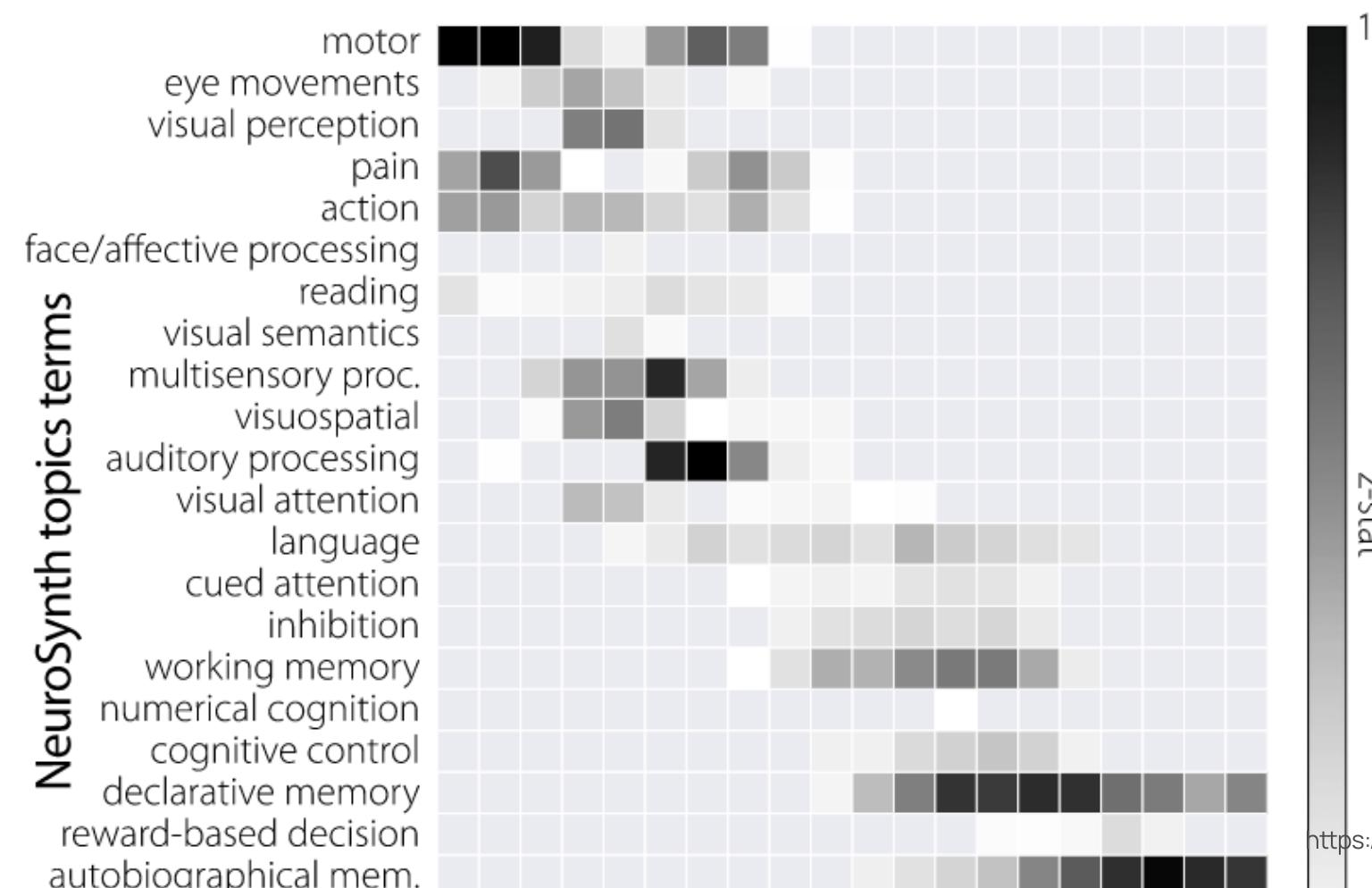


Example of Neurosynth usage

Situating the default-mode network along a principal gradient of macroscale cortical organization

Daniel S. Margulies^{a,1}, Satrajit S. Ghosh^{b,c}, Alexandros Goulas^d, Marcel Falkiewicz^a, Julia M. Huntenburg^{a,e}, Georg Langs^{f,g}, Gleb Bezgin^h, Simon B. Eickhoff^{i,j}, F. Xavier Castellanos^{k,l}, Michael Petrides^m, Elizabeth Jefferies^{n,o}, and Jonathan Smallwood^{n,o}

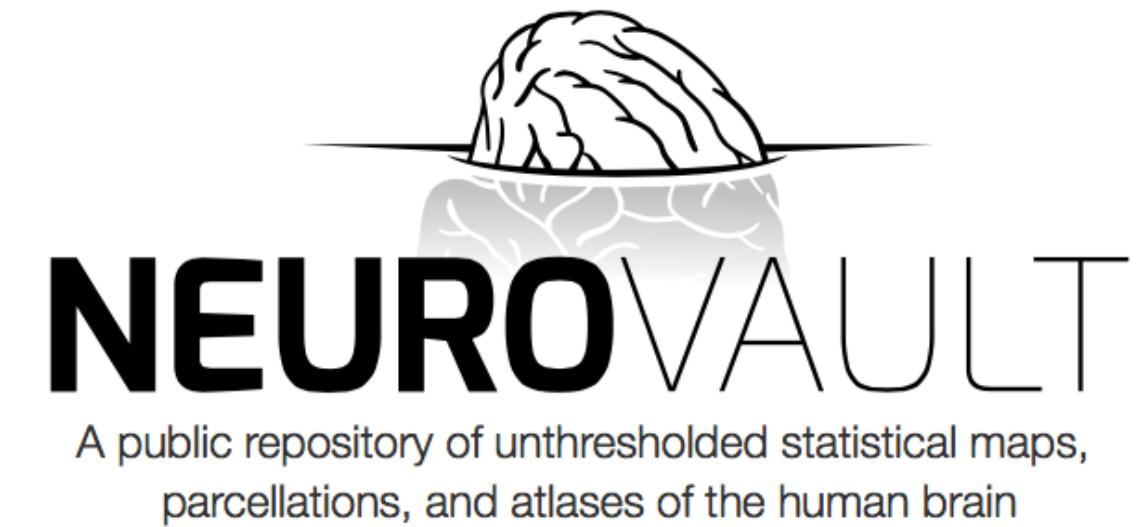
12574–12579 | PNAS | November 1, 2016 | vol. 113 | no. 44



- Identified gradients of functional organization across the cortex
- Used Neurosynth to identify the most common terms associated with each gradient

Neurovault: Sharing neuroimaging results

- The results of most neuroimaging studies are images with statistical estimates at each voxel
- Neurovault.org is an open archive for these results



- Collections

- A set of images (such as all images from a particular paper) can be uploaded as a collection
- Each collection receives a persistent identifier

NeuroVault Collections ▾ Metaanalyses ▾ About ▾ RussPoldrack ▾ Search Search

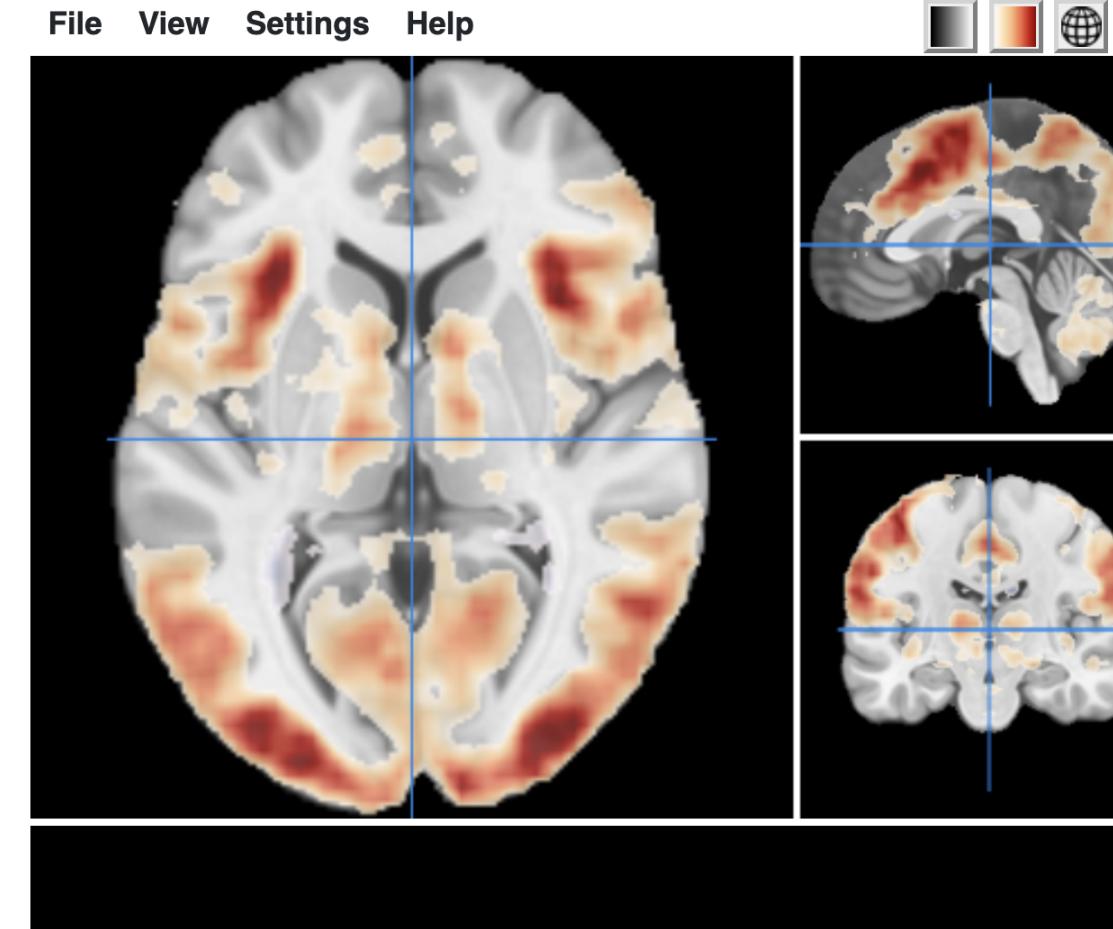
Preprocessed Consortium for Neuropsychiatric Phenomics dataset

Related article: <http://doi.org/10.12688/f1000research.11964.2>

Source data:

3D View Download

File View Settings Help



Group Metadata

Show 7 entries Search:

View	ID	Name	Type
	49974	BART Accept	T map
	49975	BART AcceptParam - ExplodeParam	T map
	49976	BART AcceptParam - RejectParam	T map
	49977	BART AcceptParametric	T map
	49978	BART Accept_RT	T map
	49979	BART Control	T map
	49980	BART Explode - Reject	T map

Showing 1 to 7 of 178 entries First Previous Next Last

Citation guidelines

If you use the data from this collection please include the following persistent identifier in the text of your manuscript:

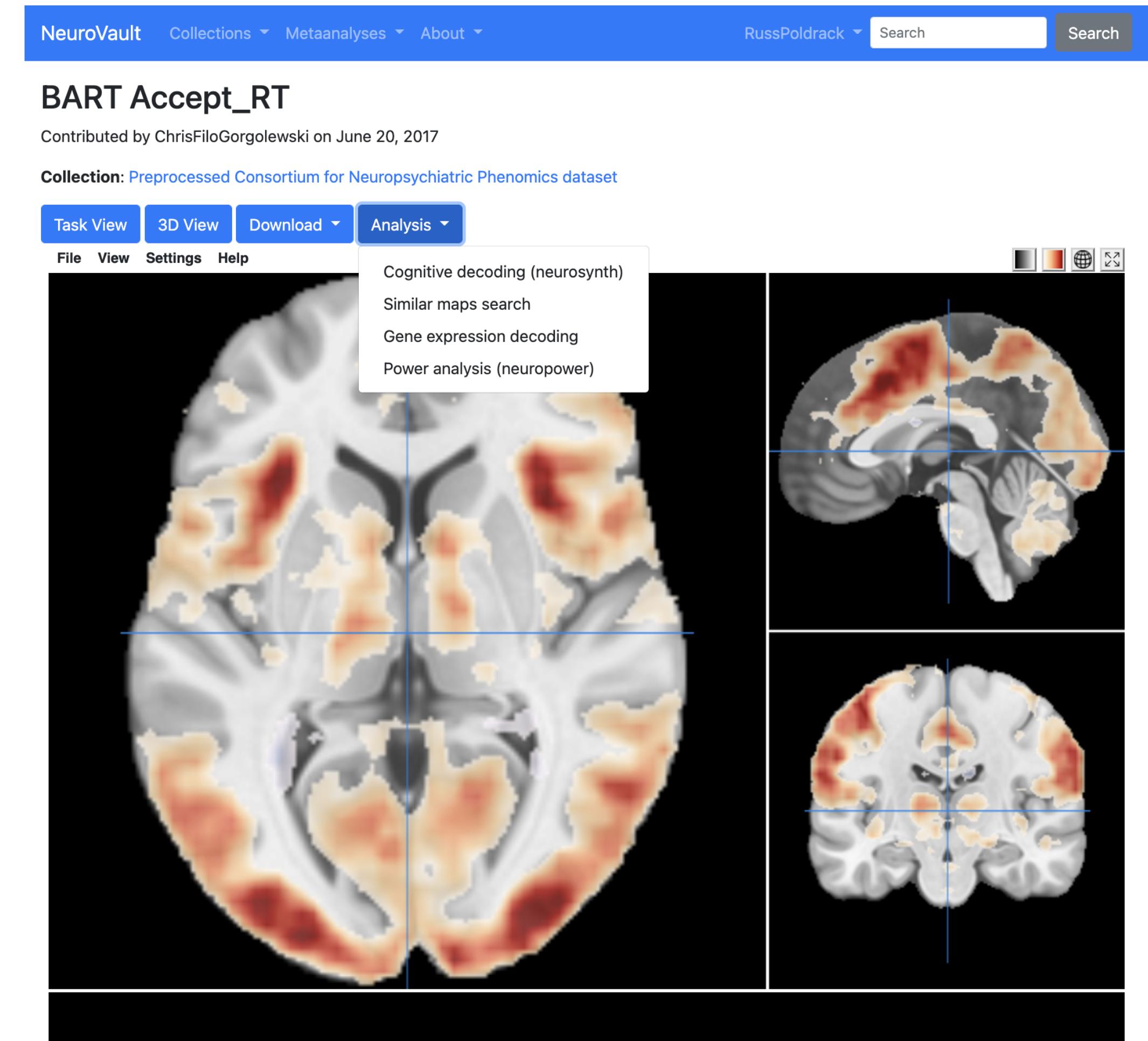
<https://identifiers.org/neurovault.collection:2606>

<https://poldrack.github.io/talks-OpenScienceEcosystem/>

This will help to track the use of this data in the literature. In addition, consider also citing the paper related to this collection.

- **Image browser**

- Individual images can be browsed and downloaded
- A number of analysis tools can also be applied
- Each image also receives a persistent identifier

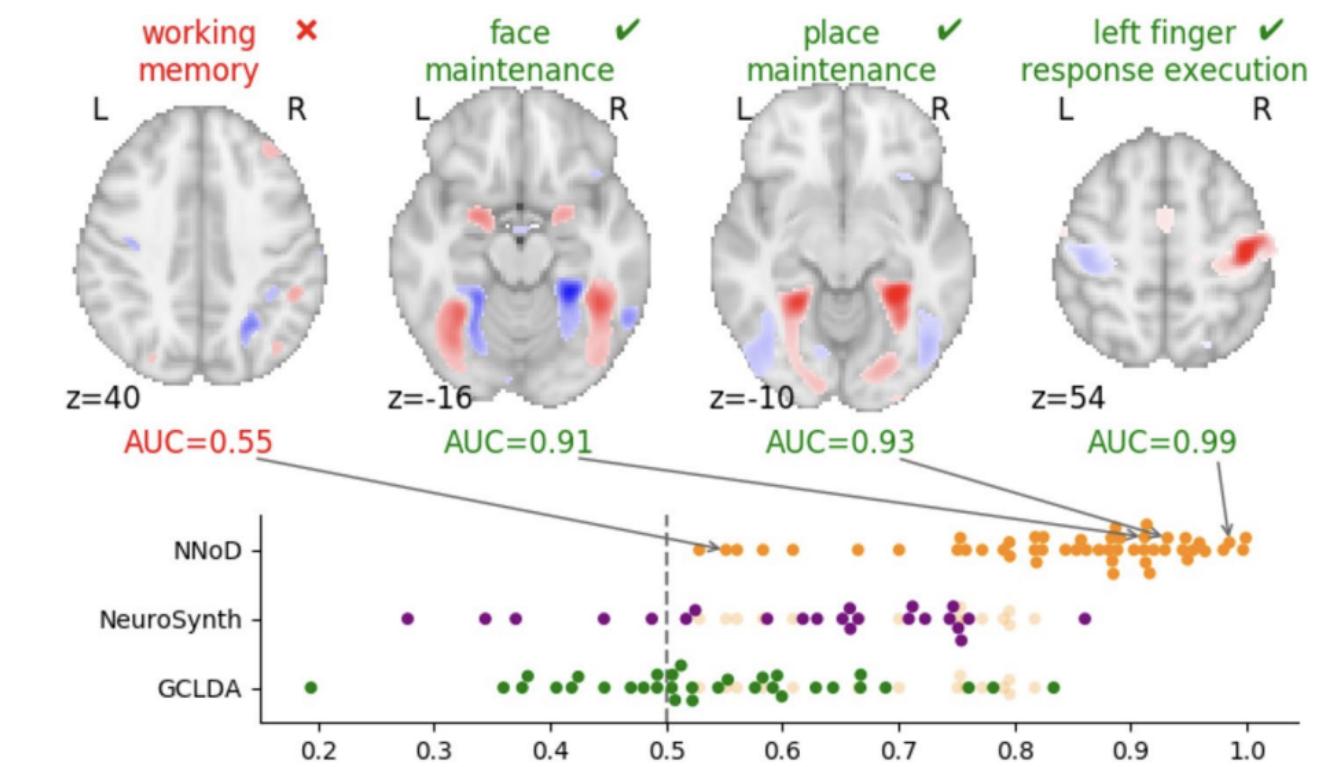
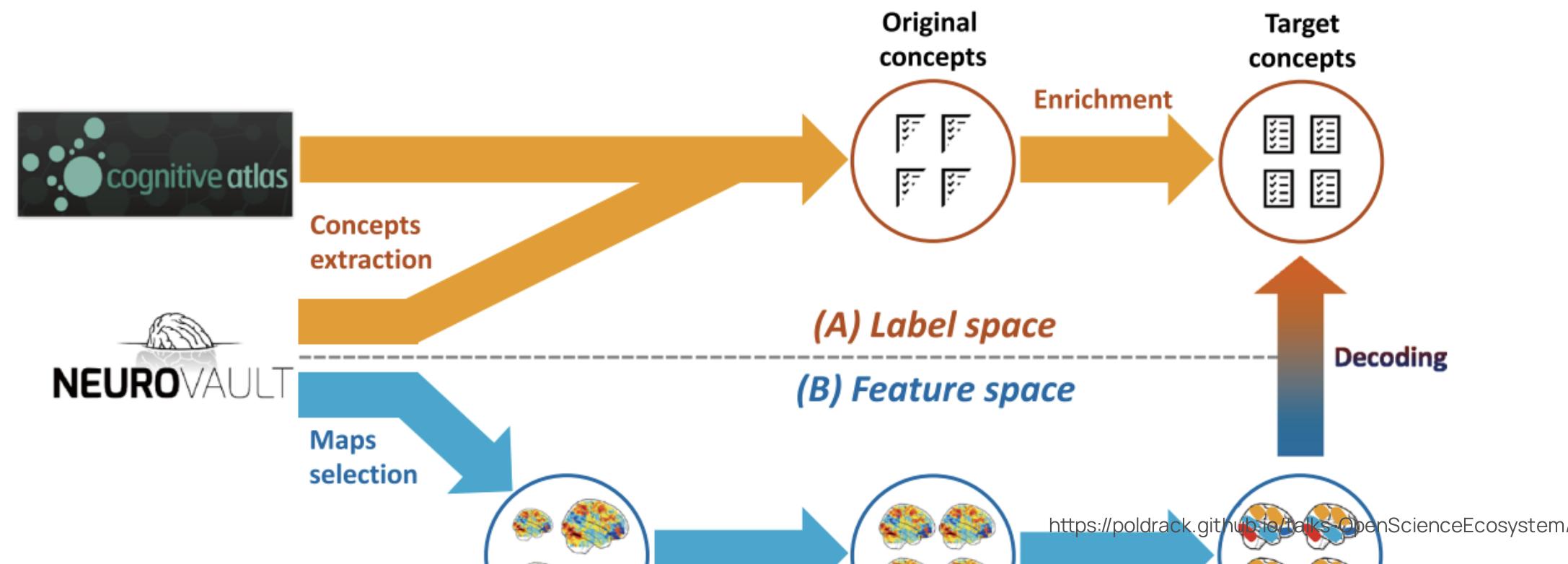


Example of Neurovault usage

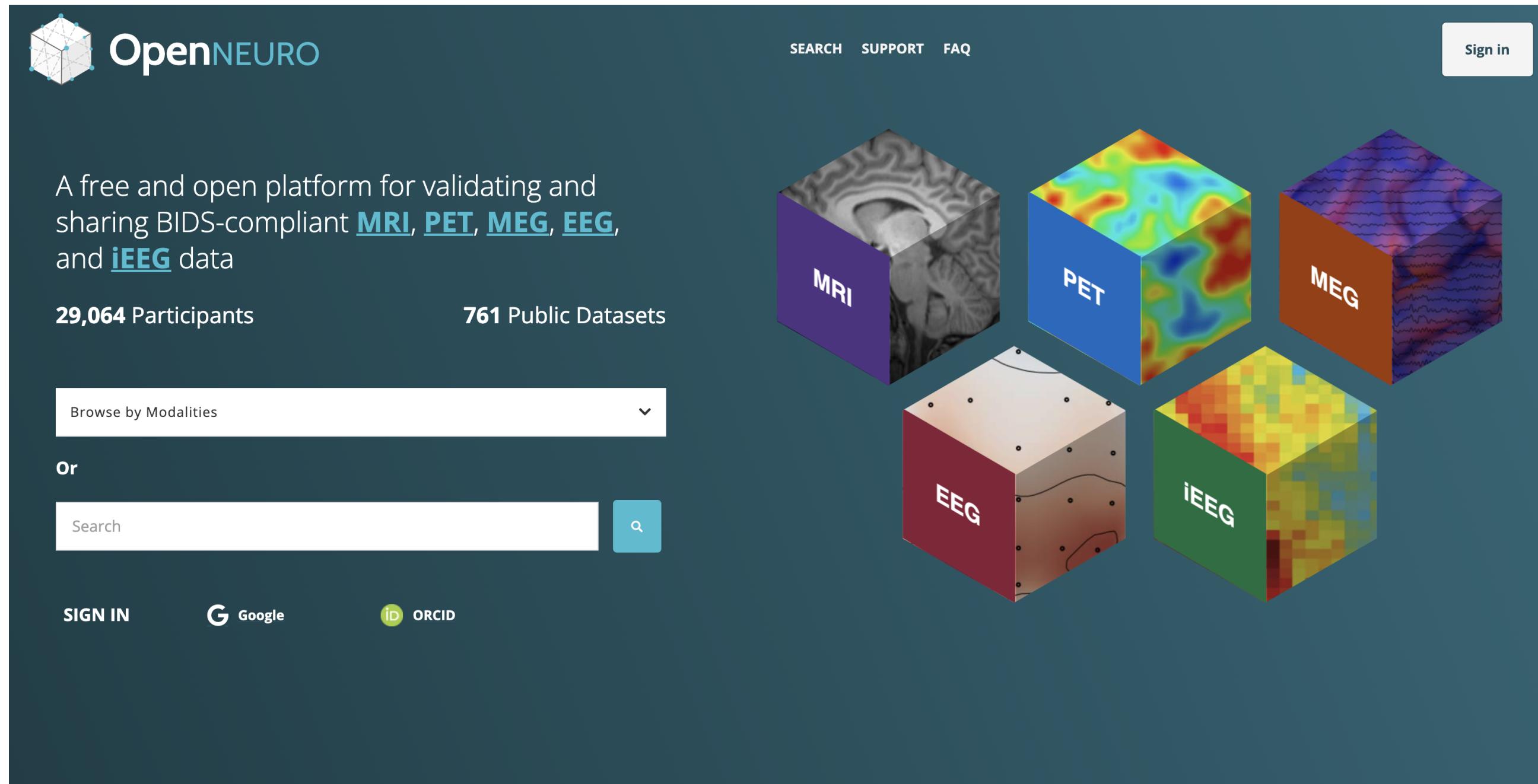
Comprehensive decoding mental processes from Web repositories of functional brain images

Romuald Menuet^{5,6}, Raphael Meudec^{1,2,3,6}, Jérôme Dockès⁴, Gael Varoquaux^{1,2,3} & Bertrand Thirion^{1,2,3✉}

Scientific Reports | (2022) 12:7050



OpenNeuro: Sharing raw and processed neuroimaging data



Validation Using BIDS

The [Brain Imaging Data Structure](#) (BIDS) is an emerging standard for the organization of neuroimaging data.

Want to contribute to BIDS?

Visit the [Google discussion group](#) to contribute.



OpenNeuro Runs on DataLad

Want to access OpenNeuro datasets with DataLad? Visit the [dataset collection on GitHub](#).

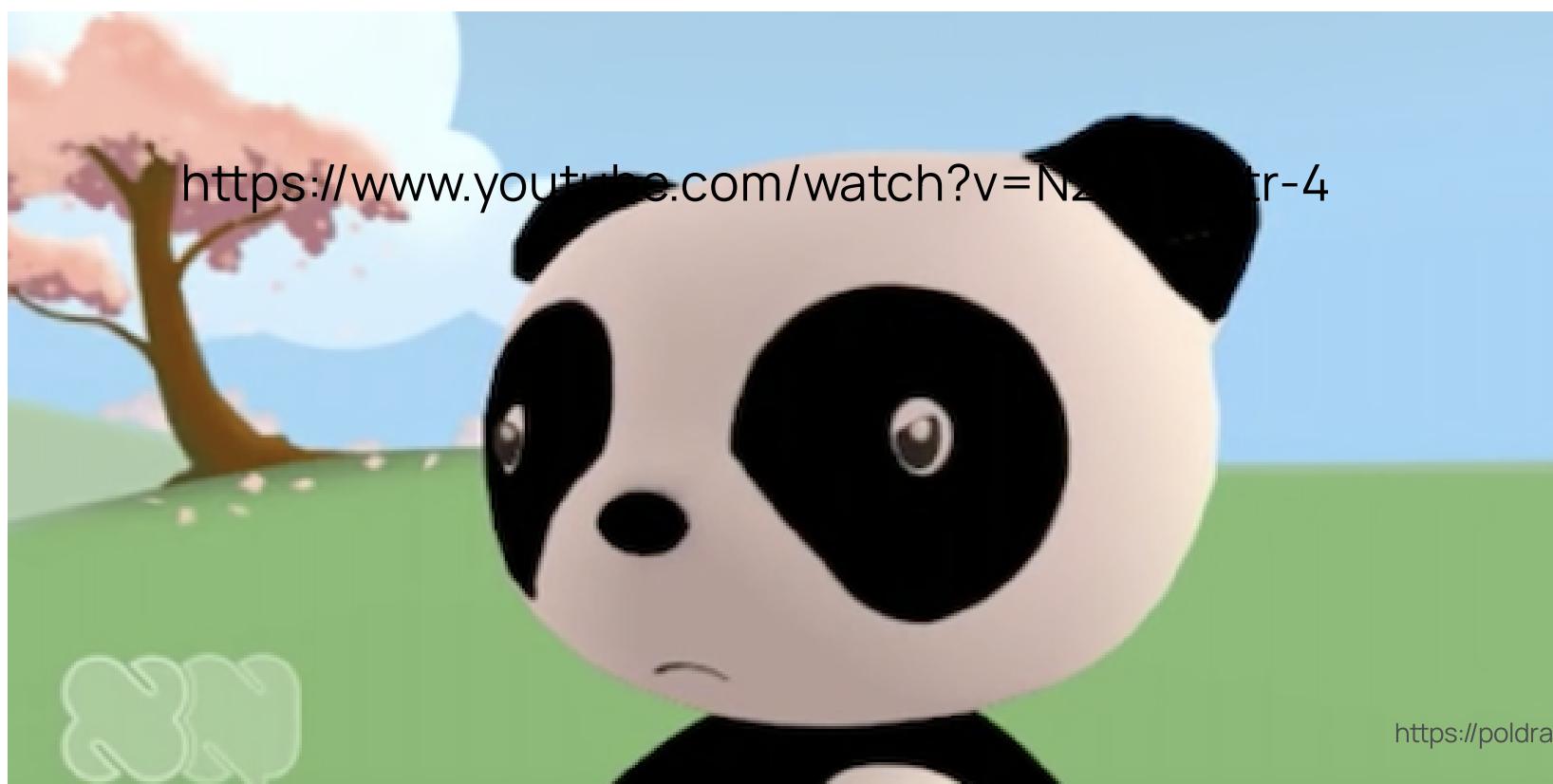
<https://poldrack.github.io/talks-OpenScienceEcosystem/>

A data management solution built on Git and Git-

Simply sharing data is not sufficient
It must be shared in a way that makes it useful!

It's easy to share data badly

Data Sharing and Management Snafu in 3 Short Acts



- I received the data, but when I opened it up it was in hexadecimal
- Yes, that is right
- I cannot read hexadecimal
- You asked for my data and I gave it to you. I have done what you asked.

Brain Imaging Data Structure (BIDS)

- A community-based open standard for neuroimaging data
 - A file organization standard
 - A metadata standard



Received: 18 December 2015

Accepted: 19 May 2016

Published: 21 June 2016

Krzysztof J. Gorgolewski¹, Tibor Auer², Vince D. Calhoun^{3,4}, R. Cameron Craddock^{5,6}, Samir Das⁷, Eugene P. Duff⁸, Guillaume Flandin⁹, Satrajit S. Ghosh^{10,11}, Tristan Glatard^{7,12}, Yaroslav O. Halchenko¹³, Daniel A. Handwerker¹⁴, Michael Hanke^{15,16}, David Keator¹⁷, Xiangrui Li¹⁸, Zachary Michael¹⁹, Camille Maumet²⁰, B. Nolan Nichols^{21,22}, Thomas E. Nichols^{20,23}, John Pellman⁶, Jean-Baptiste Poline²⁴, Ariel Rokem²⁵, Gunnar Schaefer^{1,26}, Vanessa Sochat²⁷, William Triplett¹, Jessica A. Turner^{3,28}, Gaël Varoquaux²⁹ & Russell A. Poldrack¹

The development of BIDS

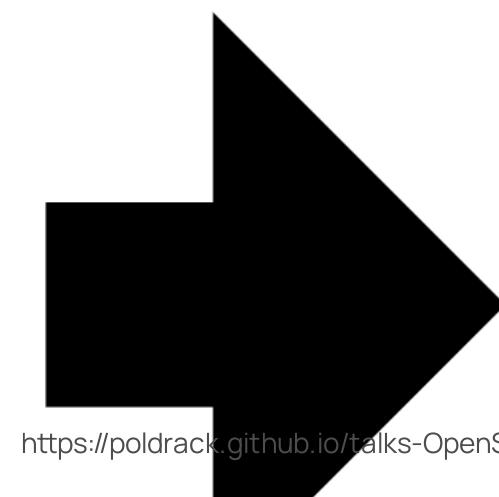
- January 2015
 - Initial stakeholder meeting at Stanford (funded by INCF)
 - Initiated development of a draft standard
- September 2015
 - Draft standard posted to BIDS web site with 22 example datasets
 - Solicited feedback from community
- ≡ • June 2016

BIDS Principles

- *Adoption is crucial*
 - Keep it as similar to existing practices as possible
 - Don't let technology override usability!
 - Focus on engaging the community
- *Don't reinvent the wheel*
 - Use existing standards when possible
- ≡ • *80/20 rule*

From DICOM to BIDS

dicomdir/
 1208200617178_22/
 1208200617178_22_8973.dcm
 1208200617178_22_8943.dcm
 1208200617178_22_2973.dcm
 1208200617178_22_8923.dcm
 1208200617178_22_4473.dcm
 1208200617178_22_8783.dcm
 1208200617178_22_7328.dcm
 1208200617178_22_9264.dcm



my_dataset/
 participants.tsv
 sub-01/
 anat/
 sub-01_T1w.nii.gz
 func/
 sub-01_task-rest_bold.nii.gz
 sub-01_task-rest_bold.json
 dwi/
 sub-01_dwi.nii.gz

The importance of automated validation

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.

BIDS Extensions

- BIDS was originally focused on structural/functional MRI data
- BIDS extension process allows extension of the standard through BIDS Extension Proposals (BEPs) initiated by the community
 - Patterned after the Python Enhancement Proposal (PEP) process

11 Completed BEPs:

BEP #	Title
-------	-------

BEP001	Quantitative MRI (qMRI)
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BEP003	Common Derivatives
--------	--------------------

BEP005	Arterial Spin Labeling (ASL)
--------	------------------------------

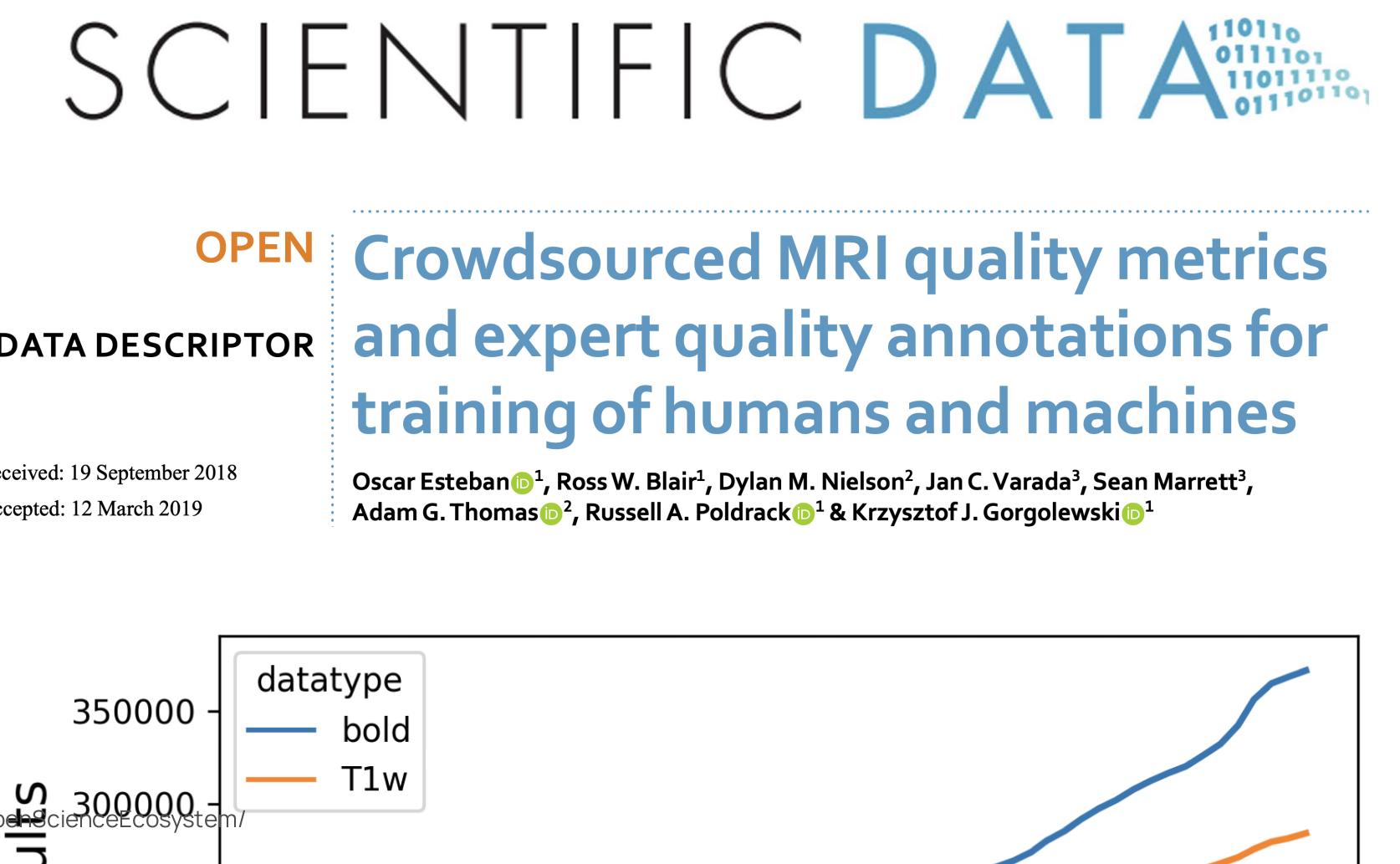
BEP006	Electroencephalography (EEG)
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BEP007	Hierarchical Event Descriptor (HED) Tags
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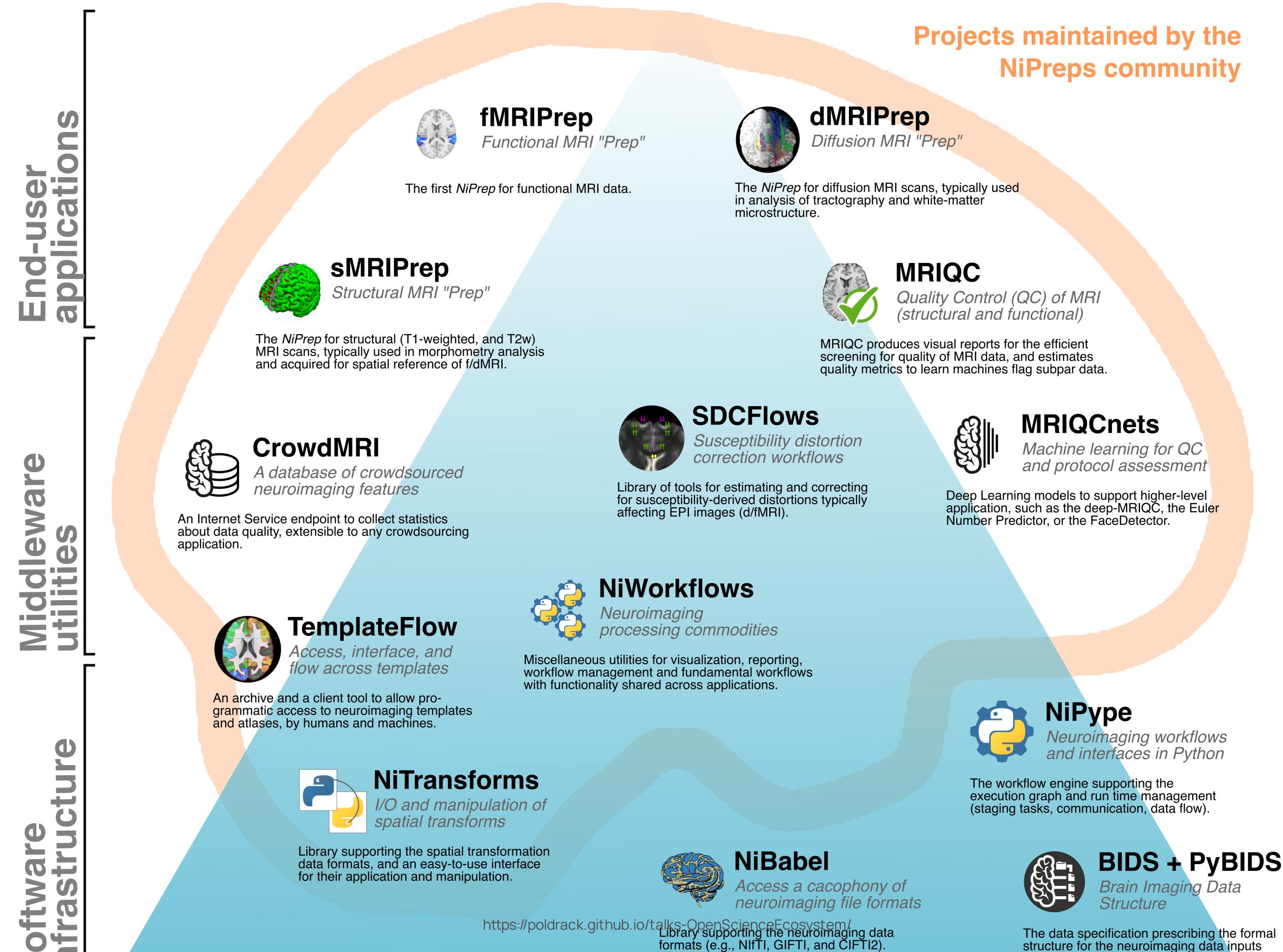
BEP008	Magnetoencephalography (MEG)
--------	------------------------------

The growing usage of BIDS: An example

- MRIQC Web API
 - Crowdsourced database of MR QC metrics
 - QC metrics from ~375K unique BOLD scans and ~280K T1w scans as of June 2022
 - Publicly available:
<https://mriqc.nimh.nih.gov/>



BIDS enables a growing open-source software ecosystem



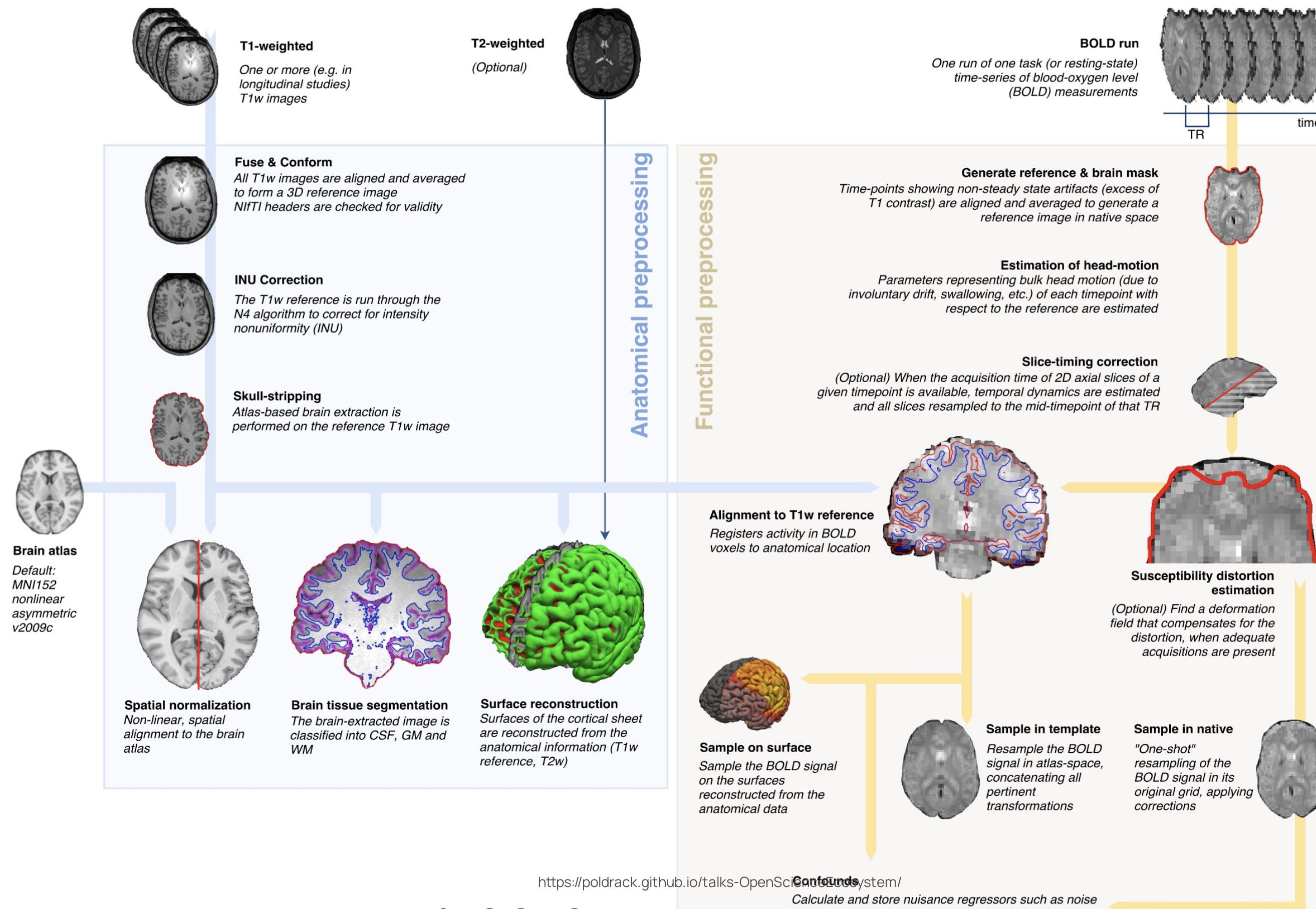
BIDS apps: Improving ease of use, accessibility, and reproducibility of neuroimaging data analysis methods

Krzysztof J. Gorgolewski^{1*}, Fidel Alfaro-Almagro², Tibor Auer³, Pierre Bellec^{4,5}, Mihai Capotă⁶, M. Mallar Chakravarty^{7,8}, Nathan W. Churchill⁹, Alexander Li Cohen¹⁰, R. Cameron Craddock^{11,12}, Gabriel A. Devenyi^{7,8}, Anders Eklund^{13,14,15}, Oscar Esteban¹, Guillaume Flandin¹⁶, Satrajit S. Ghosh^{17,18}, J. Swaroop Guntupalli¹⁹, Mark Jenkinson², Anisha Keshavan²⁰, Gregory Kiar^{21,22}, Franziskus Liem²³, Pradeep Reddy Raamana^{24,25}, David Raffelt²⁶, Christopher J. Steele^{7,8}, Pierre-Olivier Quirion¹⁵, Robert E. Smith²⁶, Stephen C. Strother^{24,25}, Gaël Varoquaux²⁷, Yida Wang⁶, Tal Yarkoni²⁸, Russell A. Poldrack¹

PLOS Computational Biology | <https://doi.org/10.1371/journal.pcbi.1005209> March 9, 2017

- Containerized applications that can be run on a BIDS dataset
 - Containers provide ease of use as well as better reproducibility

fMRIprep: Robust preprocessing of fMRI data



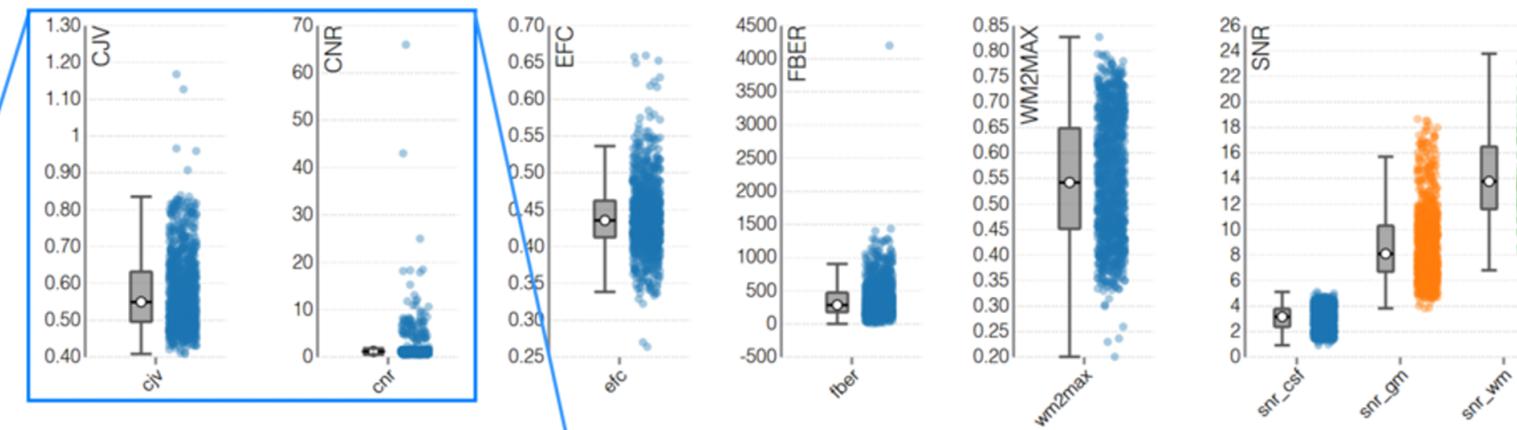
MRIQC: MRI quality control for BIDS data

1

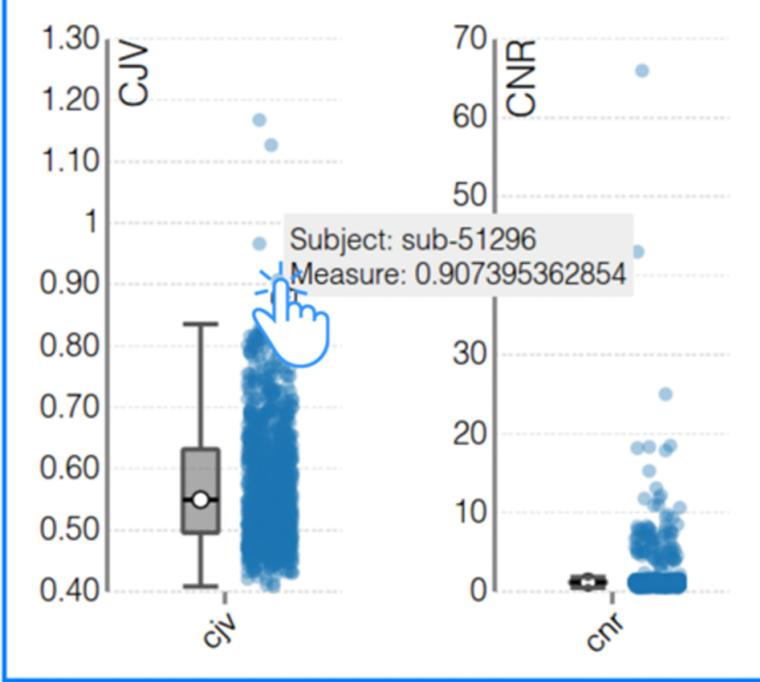
MRIQC: group anatomical report

Summary

- Date and time: 2017-02-05, 12:27.
- MRIQC version: 0.9.0-rc2.



2



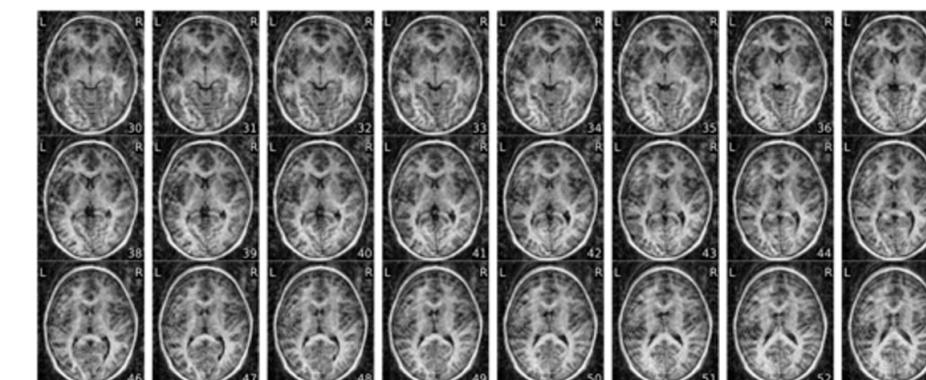
3

The individual reports show the calculated IQMs and metadata in the summary, and a series of image mosaics and plots designed for the visual assessment of images.

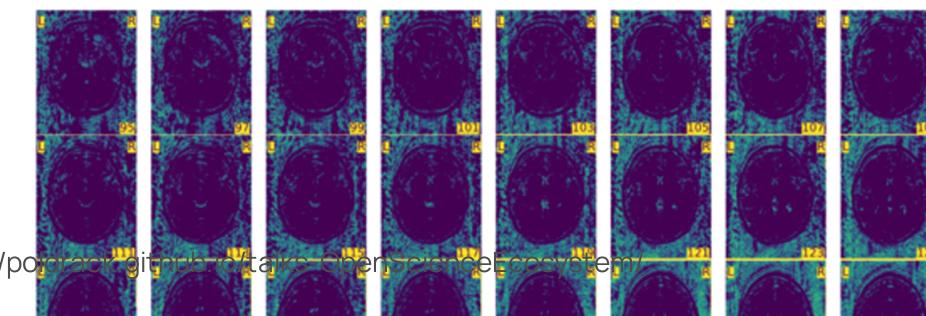
MRIQC: individual anatomical report

Summary

- Subject ID: 51296.
- Date and time: 2017-02-05, 03:44.
- MRIQC version: 0.9.0-rc2.

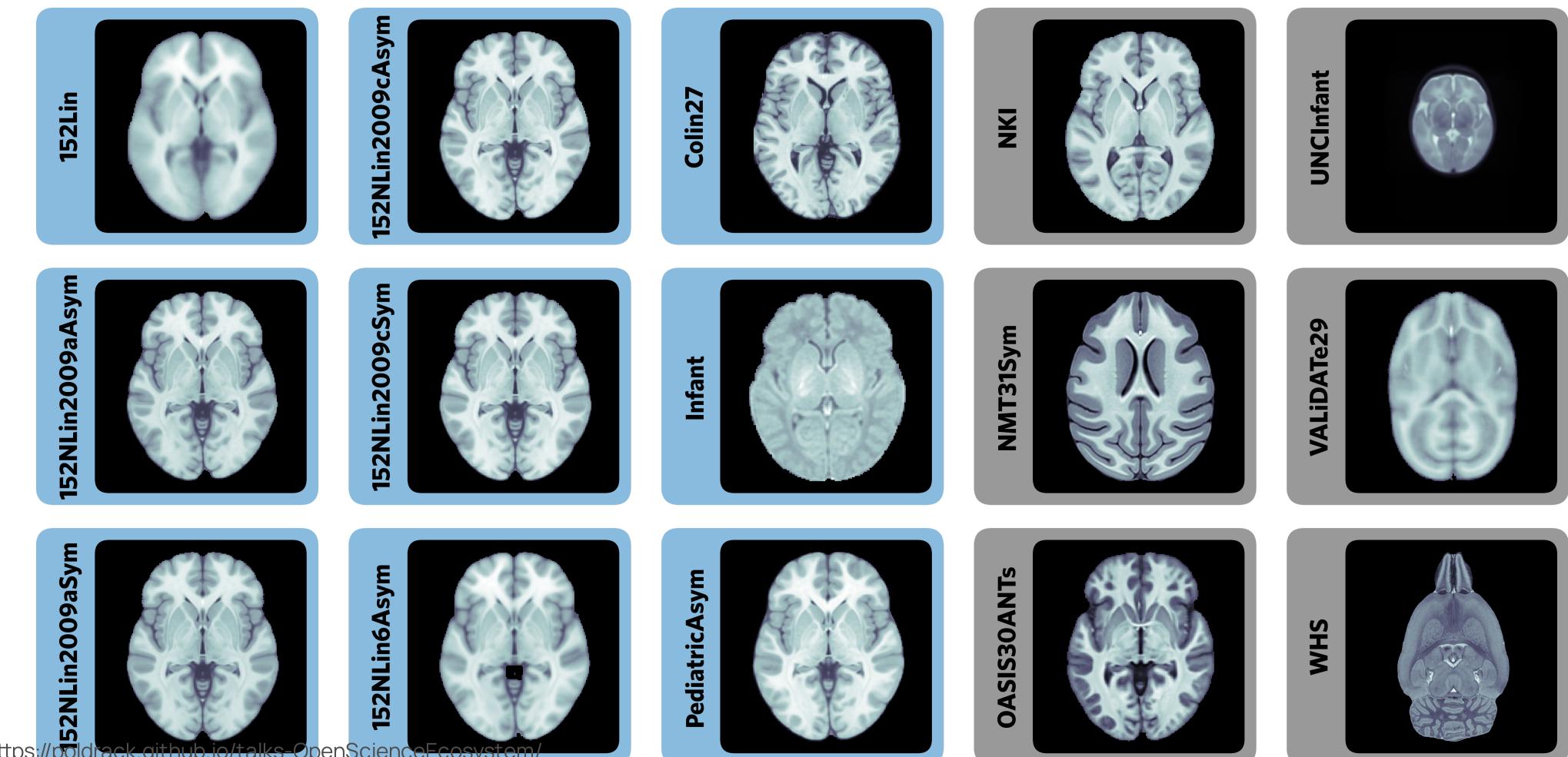


Data points in the scatter plots of the group report can be clicked to open the corresponding individual report. This feature is particularly useful to identify low-quality datasets visually.



Tenmplateflow: FAIR Sharing of Neuroimaging Templates

- Templates and atlases are commonly used in neuroimaging
- There is a significant lack of clarity in the use of these templates
 - There are numerous versions of the widely used “MNI



OpenNeuro: A BRAIN Initiative archive for BIDS data

The screenshot shows the OpenNeuro website homepage with a dark teal background. At the top left is the OpenNeuro logo. To its right are links for SEARCH, SUPPORT, and FAQ, and a Sign in button. Below the header, there's a large graphic featuring five 3D cubes representing different neuroimaging modalities: MRI (purple), PET (blue), MEG (orange), EEG (red), and iEEG (green). To the left of the cubes, text indicates there are 29,064 Participants and 761 Public Datasets. Below this, there's a dropdown menu labeled "Browse by Modalities" and a search bar containing the text "reading". At the bottom, there are links for SIGN IN, Google, and ORCID.

- Supports sharing of any validated BIDS dataset



Search All Datasets

Keywords ?



KEYWORD:
reading X

reading X

CLEAR ALL

SORT BY: Relevance ↑

The Reading Brain Project L1 Adults

Uploaded by: Chanyuan Gu on 2022-01-07 - 10 months ago | Updated: 2022-01-05 - 10 months ago



^A

MODALITIES:

MRI

MRI

PET

EEG

iEEG

MEG

TASKS:

read task

rest

OPENNEURO ACCESSION NUMBER: [ds003974](#)

SESSIONS: 1

PARTICIPANTS: 52

PARTICIPANTS' AGES: N/A

SIZE: 46.67GB

FILES: 893

<https://poldrack.github.io/talks-OpenScienceEcosystem/>

The Reading Brain Project L2 Adults



^A

Each shared dataset
is versioned and

receives a persistent
identifier (DOI)

The screenshot shows the OpenNeuro dataset page for 'The Reading Brain Project L2 Adults'. At the top, there's a navigation bar with 'SEARCH', 'SUPPORT', 'FAQ', and a 'Sign in' button. Below the header, the project title 'The Reading Brain Project L2 Adults' is displayed, along with a 'MRI' icon. To the right of the title are 'Follow' and 'Bookmark' buttons. The main content area includes a 'BIDS Validation' section with '4 WARNINGS' and a 'Valid' status, a 'Files' tab selected under 'Download' and 'Metadata' options, and a detailed 'README' section. The 'README' text provides a brief overview of the dataset, mentioning it contains the bilingual (L2) adult subset of the Reading Brain Project (RBP) data, focusing on 56 participants who underwent two sessions of testing: MRI scanning and behavioral tests. It also notes that the dataset was previously accessible at ds002317 and was reuploaded due to privacy considerations. The right side of the page displays metadata such as the 'OpenNeuro Accession Number' (ds003988), 'Authors' (Ping Li, Chun-Ting Hsu, Ben Schloss, Anya Yu, Lindsey Ma, Marissa Scotto, Friederike Seyfried, Chanyuan Gu), 'Available Modalities' (MRI), 'Versions' (1.0.0, created 2022-02-01), and 'Tasks' (read task, rest). A footer at the bottom links to methodology documents and the GitHub repository.

SEARCH SUPPORT FAQ Sign in

MRI The Reading Brain Project L2 Adults Follow 2 Bookmark 2

BIDS Validation 4 WARNINGS Valid brainlife.io Clone

Files Download Metadata

README

OpenNeuro curator note: This dataset was previously accessible at ds002317. The dataset was reuploaded due to privacy considerations.

This dataset contains the bilingual (L2) adult subset of the Reading Brain Project (RBP) data, focusing on 56 participants who underwent two sessions of testing: MRI scanning and behavioral tests tests; collected 2-3 days apart. During the first session, following the scanning of structural (T1-weighted) and resting-state data, participants performed a reading task with simultaneous eye-tracking and fMRI scanning, and the session ended with a diffusion tensor imaging (DTI) scan. The second session consisted of only behavioral tests, including five standardized tests: the Attention Network Test (ANT), Gray's Silent Reading Test (GSRT), Letter-Number Sequencing (LNS), Peabody Picture Vocabulary Test (PPVT-4), and Tower of Hanoi (ToH), followed by a survey: Reading Background Questionnaire (RBQ), which includes familiarity rating for the topics of our five reading texts. The raw data are all provided here. The first 28 subjects (sub-01 to sub-28) were native speakers of Mandarin Chinese living in the United States. Their data was collected in Hershey, PA. The second 28 subjects (sub-29 to sub-56) were native speakers of Mandarin Chinese who lived in China. Their data was collected in Beijing, China.

An updated version of the methodology document will be available at http://blclab.org/reading_brain under L2 Adult dataset/

OpenNeuro Accession Number
ds003988

Authors
Ping Li, Chun-Ting Hsu, Ben Schloss, Anya Yu, Lindsey Ma, Marissa Scotto, Friederike Seyfried, Chanyuan Gu

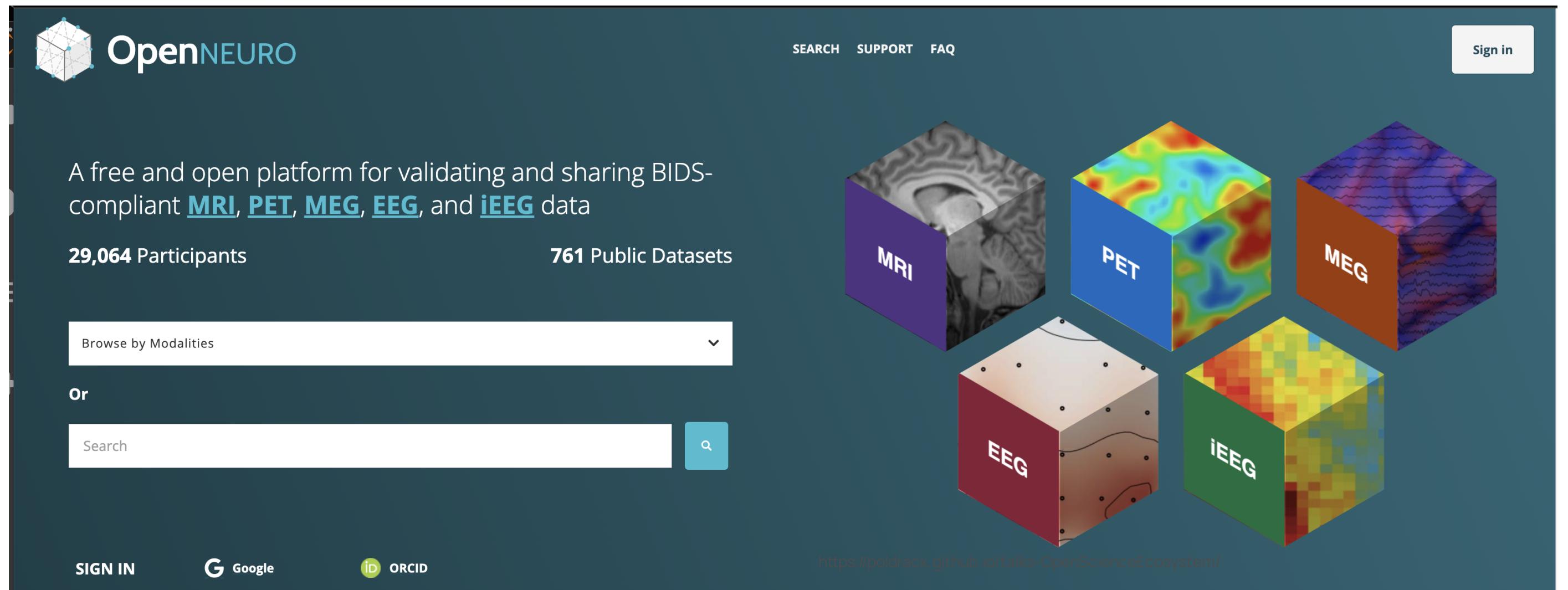
Available Modalities
MRI

Versions
1.0.0
Created: 2022-02-01 Versions

Tasks
read task, rest

https://poldrack.github.io/talks-OpenScienceEcosystem/
Uploaded by

Any valid BIDS dataset can be shared via
OpenNeuro



The image shows the homepage of the OpenNEURO platform. The header features the "OpenNEURO" logo with a brain cube icon. Navigation links include "SEARCH", "SUPPORT", "FAQ", and a "Sign in" button. Below the header, a main banner highlights "A free and open platform for validating and sharing BIDS-compliant [MRI](#), [PET](#), [MEG](#), [EEG](#), and [iEEG](#) data". It also displays statistics: "29,064 Participants" and "761 Public Datasets". A "Browse by Modalities" dropdown menu is shown, along with a search bar and a "Search" button. To the right, five 3D cube icons represent different data modalities: MRI (purple), PET (blue), MEG (orange), EEG (red), and iEEG (green). The bottom navigation bar includes "SIGN IN", "Google", "ORCID", and a "41 / 65" page indicator.

OpenNEURO

SEARCH SUPPORT FAQ Sign in

A free and open platform for validating and sharing BIDS-compliant [MRI](#), [PET](#), [MEG](#), [EEG](#), and [iEEG](#) data

29,064 Participants 761 Public Datasets

Browse by Modalities

Or

Search

SIGN IN Google ORCID 41 / 65

<https://poldrack.github.io/talks-OpenScienceEcosystem/>

The screenshot shows the OpenNEURO homepage with a dark background. In the center, a white sign-in modal is displayed. The modal features the OpenNEURO logo at the top left, followed by a "Sign in" button. Below the button are two login options: "G Google" and "iD ORCID". A small link "What is this?" is located to the right of the login buttons. At the bottom right of the modal is another "Sign in" button. The main page behind the modal includes the following text and statistics:

OpenNEURO

A free and open platform for validating and sharing compliant **MRI**, **PET**, **MEG**, **EEG**, and **iEEG** data.

29,064 Participants

761 Public Datasets

Browse by Modalities

Or

Search

SIGN IN G Google iD ORCID

https://poldrack.github.io/talks-OpenScienceEcosystem/

The screenshot shows the homepage of the OpenNEURO platform. At the top, there is a navigation bar with links for SEARCH, SUPPORT, FAQ, UPLOAD (which is underlined), and My Account. Below the navigation bar, there is a large banner featuring five 3D cubes, each representing a different neuroimaging modality: MRI (purple), PET (blue), MEG (orange), EEG (red), and iEEG (green). To the left of the banner, there is a section with the text "A free and open platform for validating and sharing BIDS-compliant [MRI](#), [PET](#), [MEG](#), [EEG](#), and [iEEG](#) data". Below this text, there are two statistics: "29,064 Participants" and "761 Public Datasets". Further down, there is a dropdown menu labeled "Browse by Modalities" and a search bar with a magnifying glass icon. At the bottom of the page, there is a footer with the URL <https://poldrack.github.io/talks-OpenScienceEcosystem/> and a page number "43 / 65".

SEARCH SUPPORT FAQ UPLOAD

My Account

A free and open platform for validating and sharing BIDS-compliant [MRI](#), [PET](#), [MEG](#), [EEG](#), and [iEEG](#) data

29,064 Participants

761 Public Datasets

Browse by Modalities

Or

Search

https://poldrack.github.io/talks-OpenScienceEcosystem/

43 / 65



OpenNEURO

A free and open platform for validating compliant **MRI**, **PET**, **MEG**, **EEG**, and

29,064 Participants

Browse by Modalities

Or

Search

Upload Dataset

Step 1: Select Files

Step 2: Validation

Step 3: Metadata

Step 4: Accept Terms

To protect the privacy of the individuals who have been scanned, we require that all scan data be defaced before publishing a dataset.

Select a BIDS dataset to upload

Select folder

close



OpenNEURO

MRI Rhyme judgment Edit

This dataset is public.

BIDS Validation View

Files Share Versioning Admin

How to Download

Download with your browser

Upload Dataset

Step 1: Select Files Step 2: Validation Step 3: Metadata Step 4: Accept Terms

We found 3 warnings in your dataset. You are not required to fix warnings, but doing so will make your dataset more BIDS compliant. Continue or fix the issues and select folder again.

Continue

VIEW 3 WARNINGS IN 15 FILES ^

Warning: 1 VIEW 13 FILES
You should define 'SliceTiming' for this file. If you don't provide this information slice time correction will not be possible. 'Slice Timing' is the time at which each slice was acquired within each volume (frame) of the acquisition. Slice timing is not slice order -- rather, it is a list of times containing the time (in seconds) of each slice acquisition in relation to the beginning of volume acquisition.

Warning: 2 VIEW 1 FILE
<https://poldrack.github.io/talks-OpenScienceEcosystem/>
Not all subjects/sessions/runs have the same scanning parameters.

My Account

Follow 1 Bookmark 2

them public.

uro Accession Number
03

Russell A. Poldrack

lit

e Modalities

45 / 65

The screenshot shows the OpenNEURO dataset upload interface. The main header says "OpenNEURO" with a brain icon. Below it, a card for "Rhyme judgment" (MRI study) has options to "Edit" and "Share". A sidebar on the left includes "BIDS Validation" dropdown, "How to Download" section, and "Download with your browser" section. The main content area is titled "Upload Dataset" and is divided into four steps: "Step 1: Select Files", "Step 2: Validation", "Step 3: Metadata" (which is active and highlighted in dark blue), and "Step 4: Accept Terms". A note below says incomplete fields will make search harder. The "Step 3: Metadata" section contains fields for "DOI of papers from the source data lab" (with a link to "Papers that were published from the Lab that collected this dataset"), "Species" (dropdown), "Study Type" (dropdown), "Domain Studied" (text input), and "Number of Trials (if applicable)" (text input). To the right, a dark sidebar shows "My Account" with "Follow 1" and "Bookmark 2" buttons, and a list of studies like "Russell A. Poldrack" and "Modality".

OpenNEURO

MRI Rhyme judgment Edit

This dataset is public.

BIDS Validation

Files Share Versioning Admin

How to Download

Download with your browser

This method is convenient and allows you to select a local directory to download the dataset.

Steps

Upload Dataset

Step 1: Select Files Step 2: Validation Step 3: Metadata Step 4: Accept Terms

Incomplete fields in this form will make it more difficult for users to search for your dataset. We recommend completing the applicable fields to improve your search results.

DOI of papers from the source data lab

Papers that were published from the Lab that collected this dataset

Species

Study Type

Domain Studied

Number of Trials (if applicable)

My Account

Follow 1 Bookmark 2

Russell A. Poldrack

Modality

<https://poldrack.github.io/talks-OpenScienceEcosystem/>

 OpenNEURO

 Rhyme judgment 

This dataset is public.

BIDS Validation 

Files Share Versioning Admin

How to Download

Download with your browser

This method is convenient and allows you to select a local directory where you want to save the dataset. You can also choose to download a zip file containing all the files in the dataset.

Upload Dataset

Step 1: Select Files Step 2: Validation Step 3: Metadata Step 4: Accept Terms

By uploading this dataset to OpenNeuro I agree to the following conditions:

I am the owner of this dataset and have any necessary ethics permissions to share the data publicly. This dataset does not include any identifiable personal health information as defined by the [Health Insurance Portability and Accountability Act of 1996](#) (including names, zip codes, dates of birth, acquisition dates, etc). I agree to destroy any key linking the personal identity of research participants to the subject codes used in the dataset.

I agree that this dataset will become publicly available under a [Creative Commons CC0](#) license after a grace period of 36 months counted from the date of the first snapshot creation for this dataset. You will be able to apply for up to two 6 month extensions to increase the grace period in case the publication of a corresponding paper takes longer than expected. See [FAQ](#) for details.

This dataset is not subject to GDPR protections.

Generally, data should only be uploaded to a single data archive. In the rare cases where it is necessary to upload the data to two databases (such as the NIMH Data

My Account

Follow 1 Bookmark 2

Open Accession Number 03

Russell A. Poldrack

Method

Modalities

 OpenNEURO

SEARCH SUPPORT FAQ UPLOAD My Account

 Rhyme judgment Edit Following 1 Bookmark 0

This dataset has not been published! Before it can be published, please [create a version](#)

BIDS Validation ▼ 2 WARNINGS ✓ Valid Clone ▼

Files Publish Share Versioning Admin Download Metadata Delete

New Version

Create a new version of this dataset for download and public access. This will begin an export of this dataset to GitHub and S3 if it has been made public.

1.0.0 Major Minor Patch

New Changelog <https://poldrack.github.io/talks-OpenScienceEcosystem/>

OpenNeuro Accession Number
ds004338

Authors
Xue, G., Russell A. Poldrack Edit

Available Modalities
MRI

Version

Google Calendar - week of Jul 19, 2015
<https://www.google.com/calendar/render?pli=1>



OpenNEURO

SEARCH SUPPORT FAQ UPLOAD My Account

MRI Rhyme judgment Follow 1 Bookmark 2

BIDS Validation ▾

1 ERROR

! Invalid

brainlife.io

Clone ▾

OpenNeuro Accession Number

ds000003

Authors

Xue, G., Russell A. Poldrack

Available Modalities

MRI

Versions

1.0.0

Created: 2020-05-14

Versions ▾

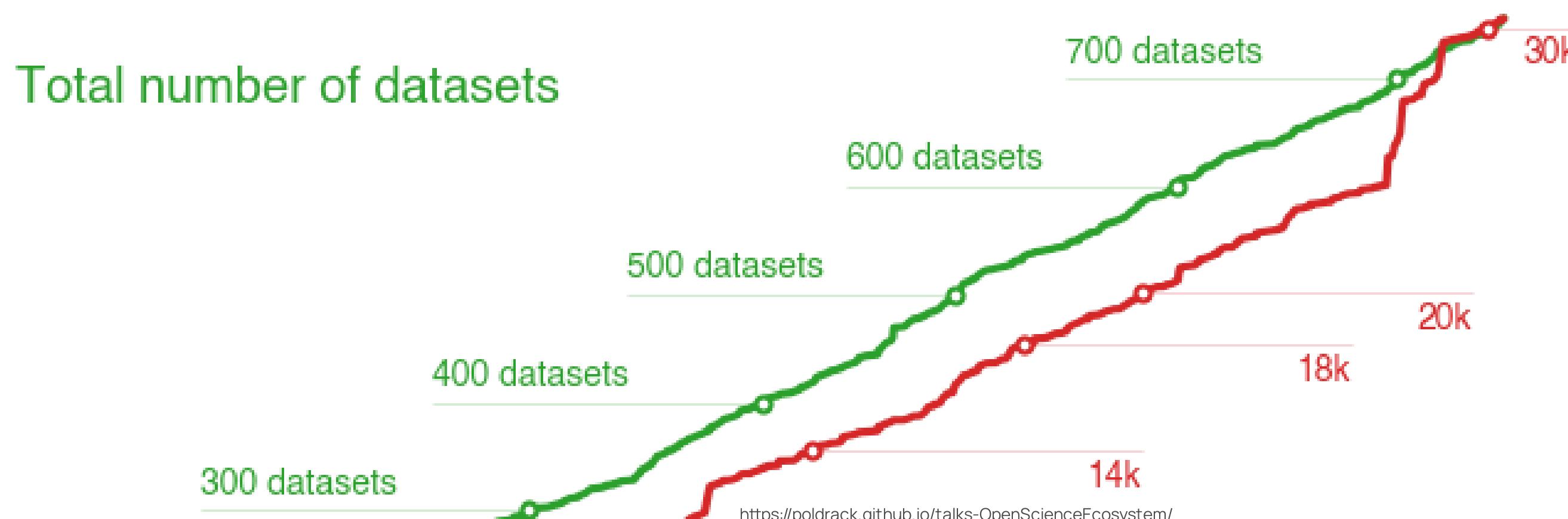
README

This dataset was obtained from the OpenfMRI project (<http://www.openfmri.org>). Accession #: ds003 Description: Rhyme judgment

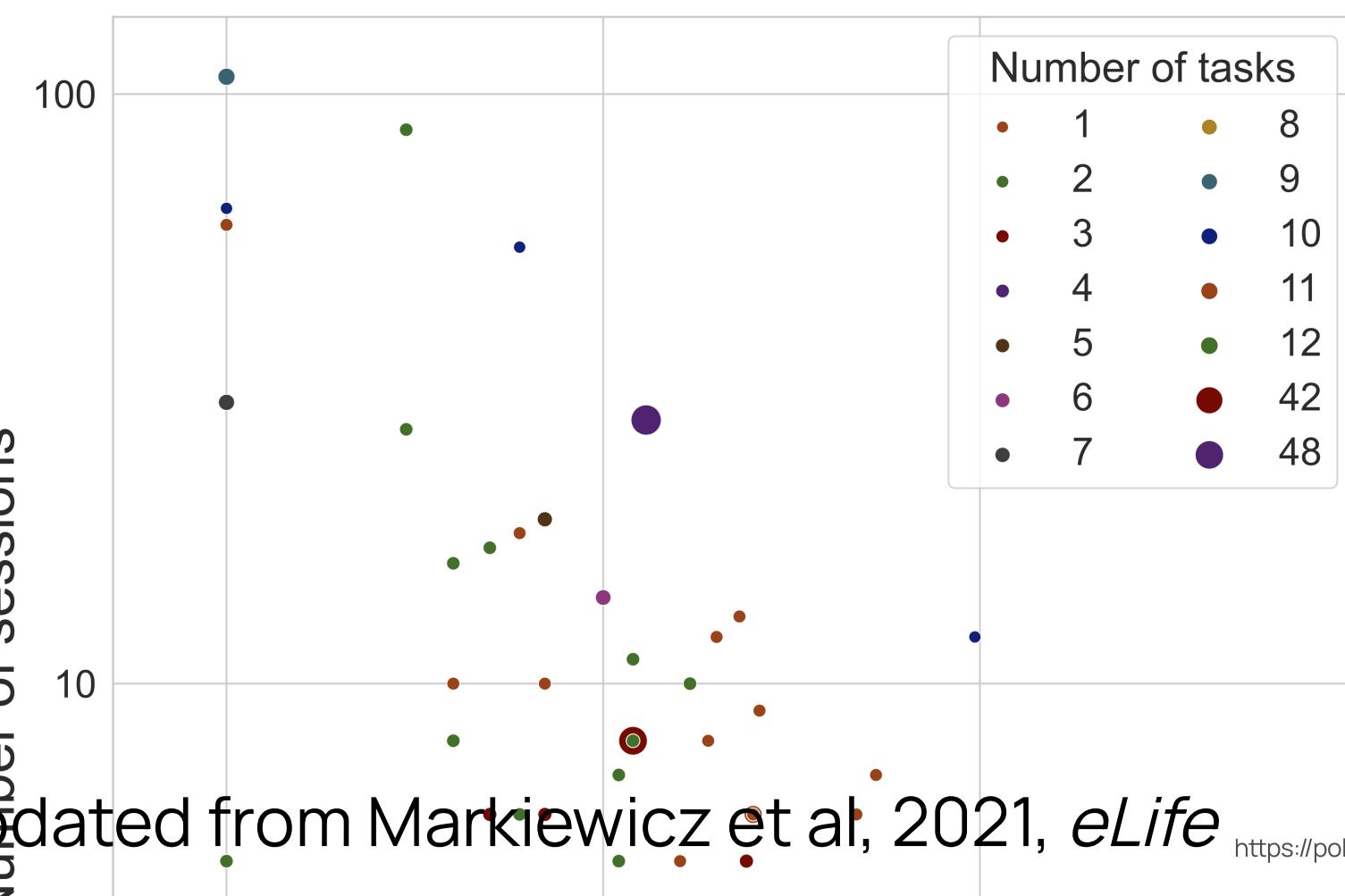
Release history: 10/06/2011: initial release 3/21/2013: Updated release with QA information 2/18/2016: Updated orientation information in nifti headers for improved left-right determination

This dataset is made available under the Public Domain Dedication and License v1.0, whose full text can be found at <http://www.opendatacommons.org/licenses/pddl/1.0/>. We hope that all users will follow the ODC Attribution/Share-Alike Community Norms (<http://www.opendatacommons.org/norms/odc-by-sa/>); in particular, while not legally required, we hope that all users of the data will acknowledge the OpenfMRI project and NSF Grant OCI-1131441 (R. Poldrack, PI) in any publications.

The growth of OpenNeuro



The diversity of OpenNeuro datasets



Datatype	#
mri - anat	597
mri - func	521
eeg	120
mri - dwi	67
meg	30
ieeg	17
beh	13

Species	#
Human	676
Mouse	20
Rat	12
NHP	2
phantoms	1
Juvenile pigs	1
Human, Mouse	1

Scholarly reuse of OpenNeuro datasets

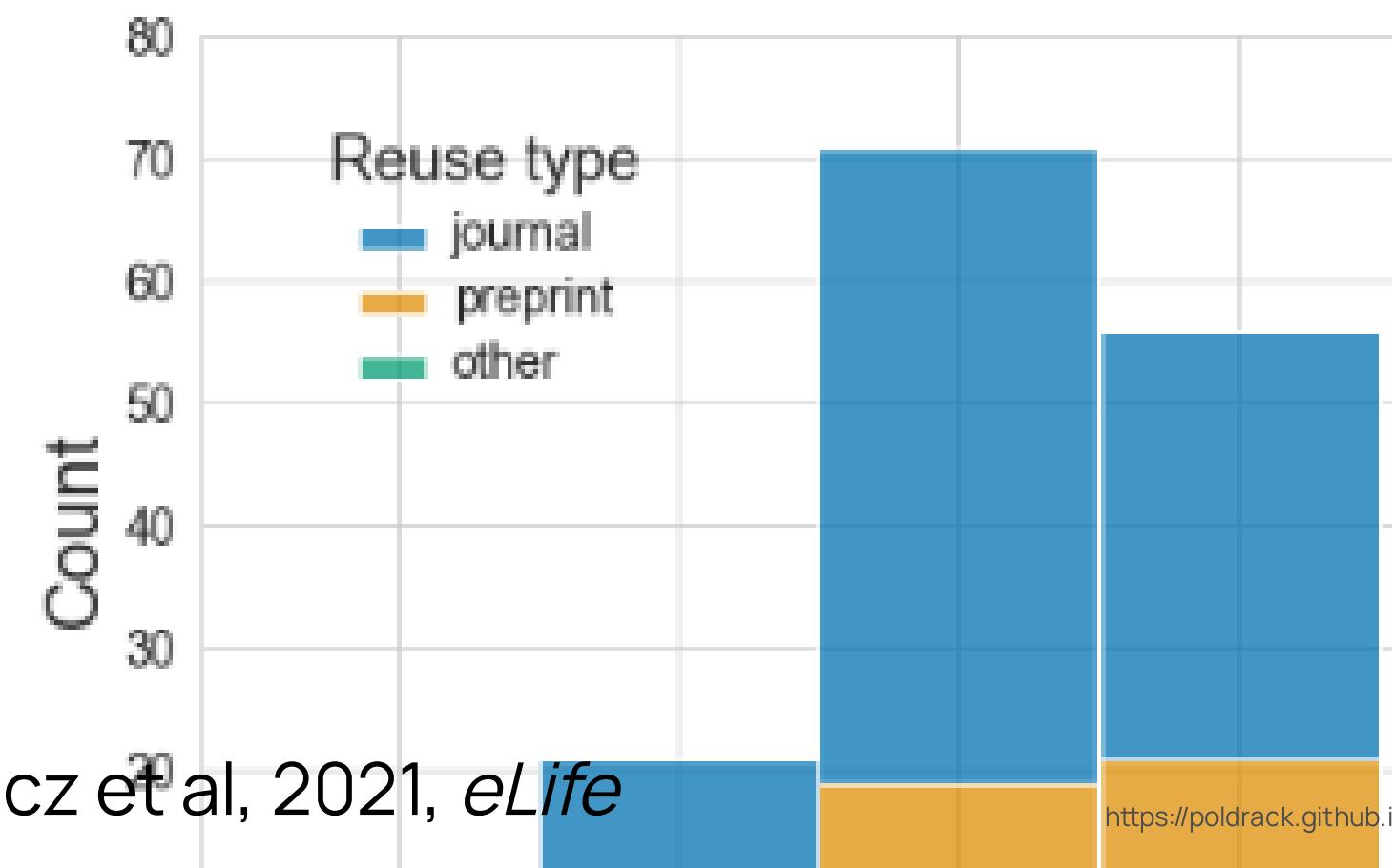


Figure 5. Published reuses of OpenNeuro datasets, split by the type of reuse. Note that the final bar includes only reuses identified through June 2021.

Processing of OpenNeuro data

brainlife.io: processing of MRI data

The screenshot shows the brainlife.io web interface. The top navigation bar includes a search bar labeled "Search Projects". The left sidebar has a blue header with the "brainlife" logo and a back arrow, followed by a list of menu items: DATASETS, PROJECTS, APPS, PUBLICATIONS, and DATATYPES. The main content area displays a grid of project cards under the heading "PUBLIC/PROTECTED PROJECTS".

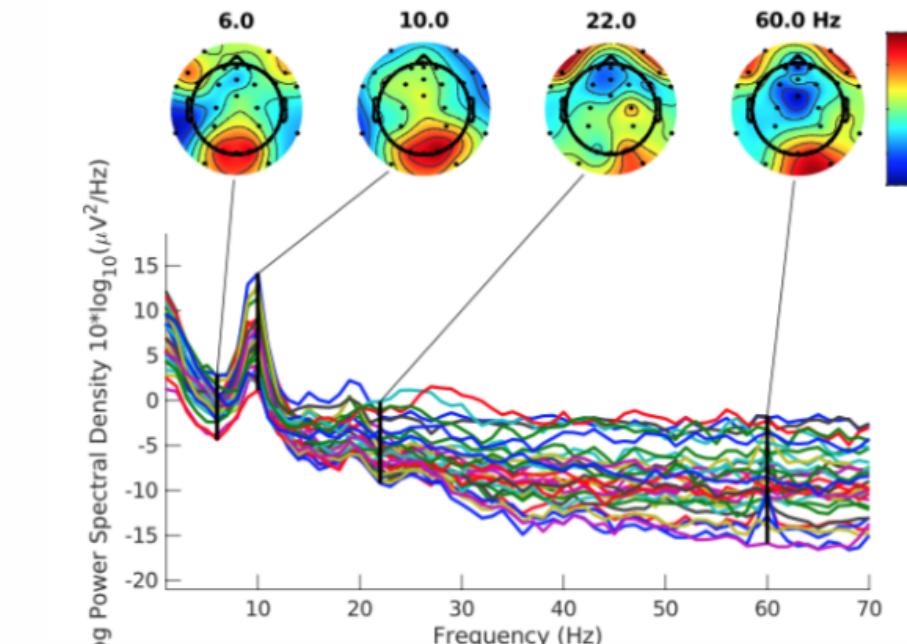
- HCP 3T / Diffusion**: 1112 sub | 6880 objs (4.51 TB). Includes links for "anat/t1w", "transform/nifti", "dwi", "hcp/freesurferpost", "raw", and "freesurfer".
- HCP 7T / Diffusion**: 150 sub | 300 objs (22.56 MB). Includes links for "anat/t1w" and "dwi". Description: "Human Connectome Project Datasets - Diffusion MRI 3T (184 out of 1200-)".
- HCP 3T Retest / Diffusion**: 45 HCP 3T subjects retested. Includes links for "transform/nifti", "dwi", "hcp/freesurferpost", "anat/t2w", "freesurfer", and "anat/t1w".
- O3D**: A reference repository for precision. Includes links for "networkneuro", "freesurfer", "anat/t1w", "wmc-deprecated", "dwi", "dtiinit", "recon", "track/tck", "LiFE", and "track/trk". Description: "O3D (Open Diffusion Data and Derivative) is a reference repository for precision".

NEM

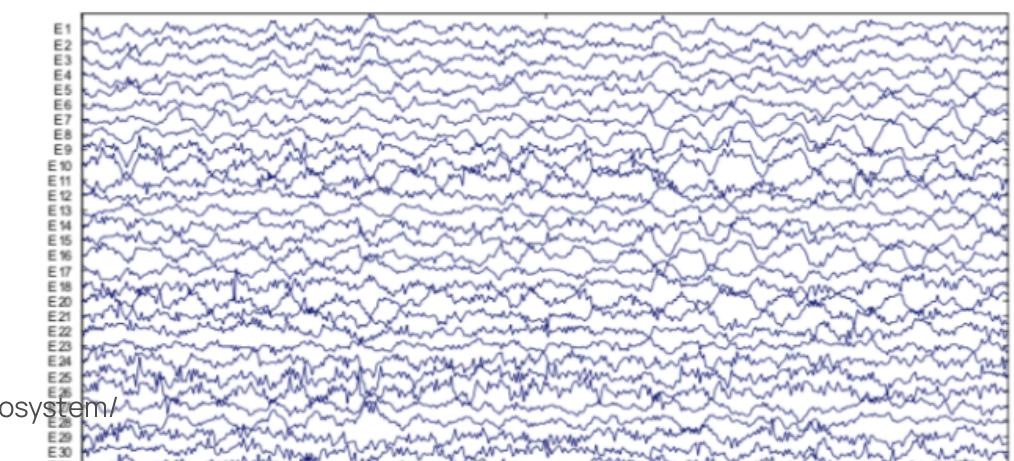
Data Summary

Subject: sub-001
Session(s): 1, **Run(s):** 1
Data size: 32 channels, 298k frames
Acceptable scalp channels: 100.0% (32 of 32) ⓘ
Acceptable data points channels: 90.9% (271k of 298k) ⓘ
Source quality metric based on independent component: 48.4% ⓘ

Scalp channel log spectra

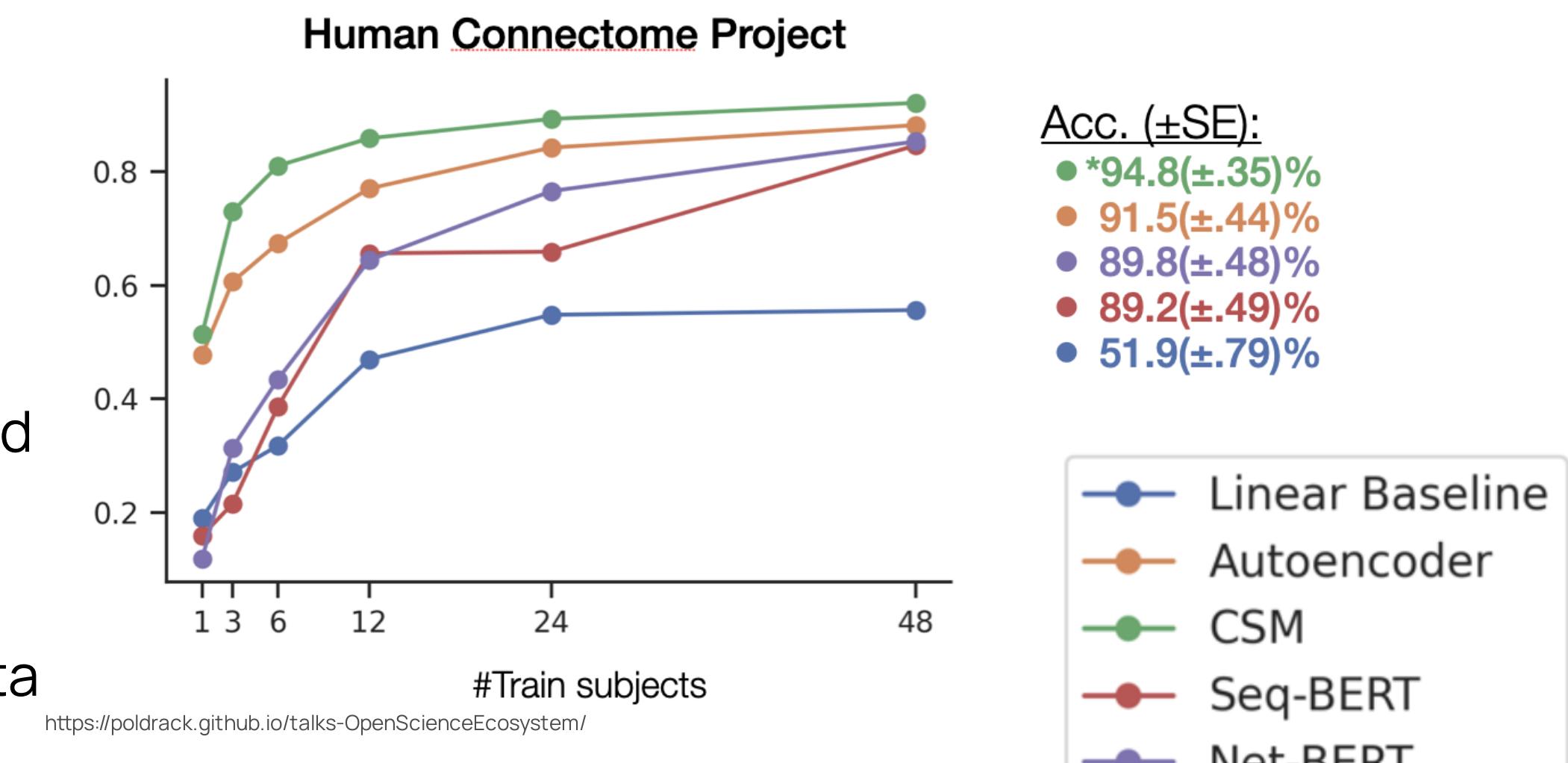


Sample scalp channel data (mid 2 seconds)



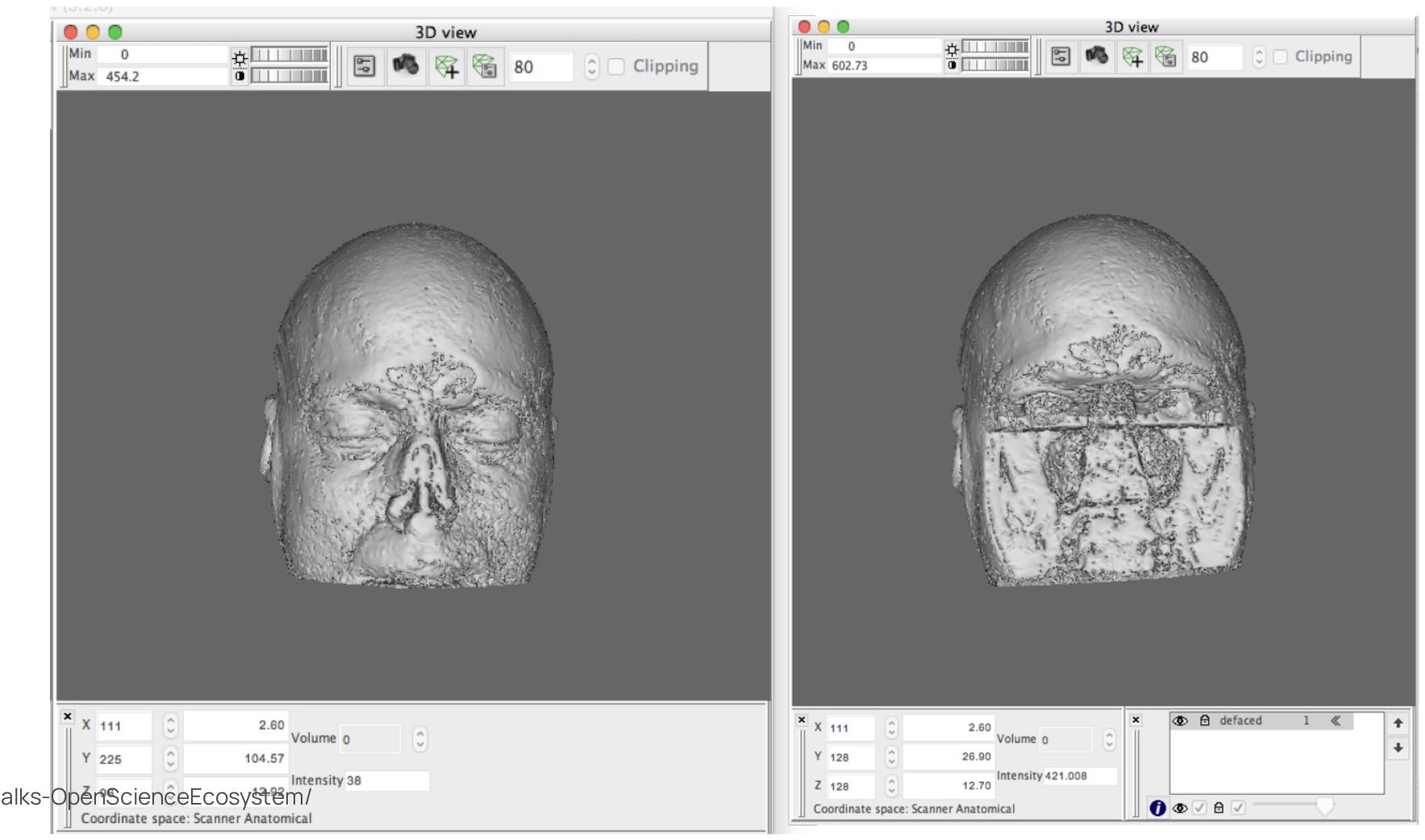
Example of OpenNeuro reuse

- A challenge for decoding brain activity from fMRI data is that most datasets are very small
- We used OpenNeuro to train a “foundation model”
 - A pre-trained model that can be used as a starting point for decoding models on smaller datasets
- We pre-train models on broad fMRI data from OpenNeuro: 11,980 experimental



Challenges to open sharing

- All OpenNeuro MRI datasets must be *defaced*
 - To reduce risk of reidentification
- There is increasing risk that subjects might be reidentified even after defacing using advanced face recognition systems + face imputation tools (Schwartz et al., 2021)
- If the risk continues to rise, it may become necessary to move away from open sharing
 - This would be a huge loss for researchers, research participants, and the world



Keys to success in neuroimaging data sharing

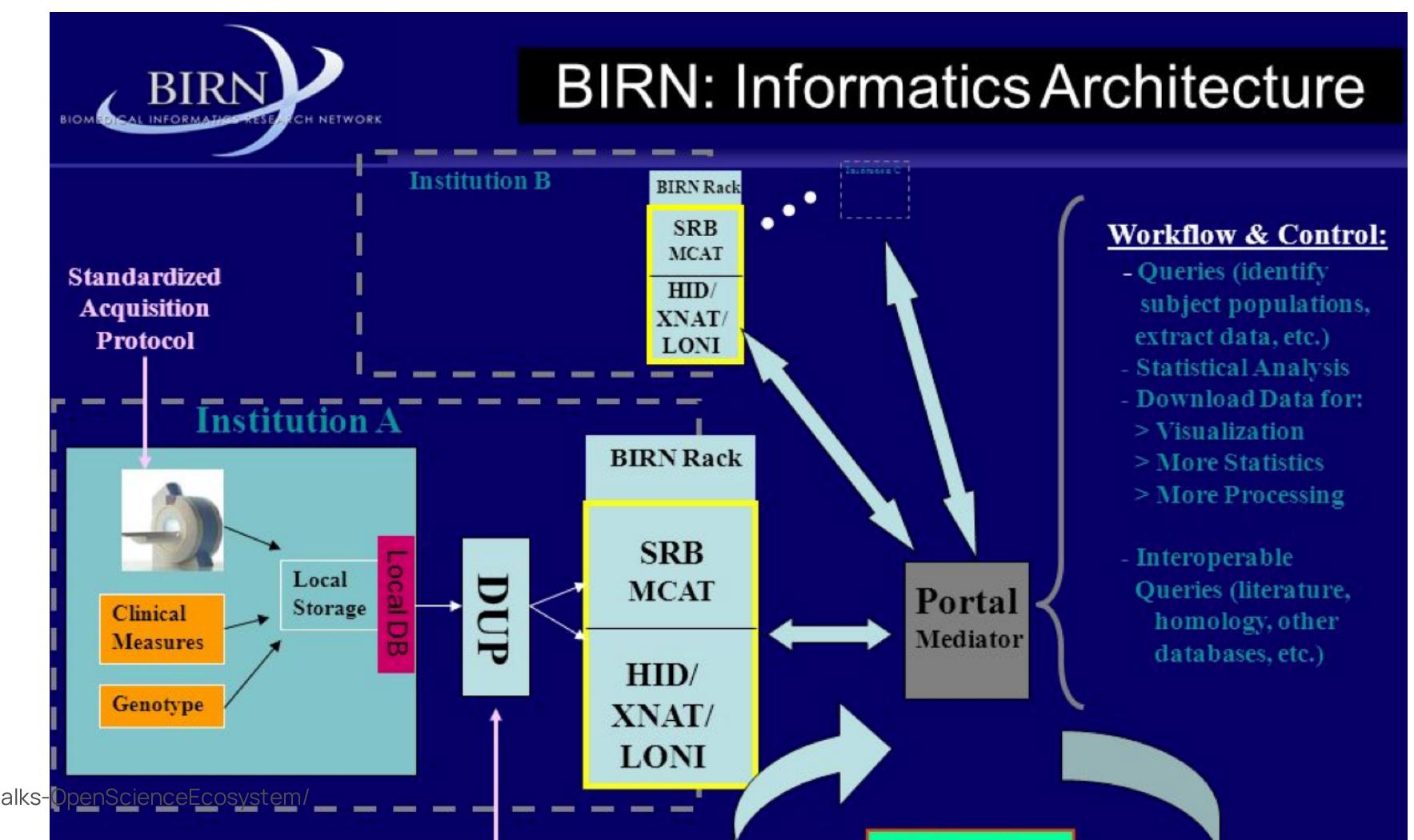
- *Data are digital end-to-end*
 - Minimizes manual steps in the process
- *Standardized file formats and data standards*
 - Makes data immediately usable by anyone
 - Reduces burden of curation and preparation
- *Demonstrated scientific utility*
- ≡ • *Numerous success stories*

Lessons learned

- Community buy-in is essential
 - Mandates put in place before the community is ready can backfire
 - Unless they have overwhelmingly powerful advocates, as in genomics
 - Important that sharing advocates are members of community and eat their own dog food

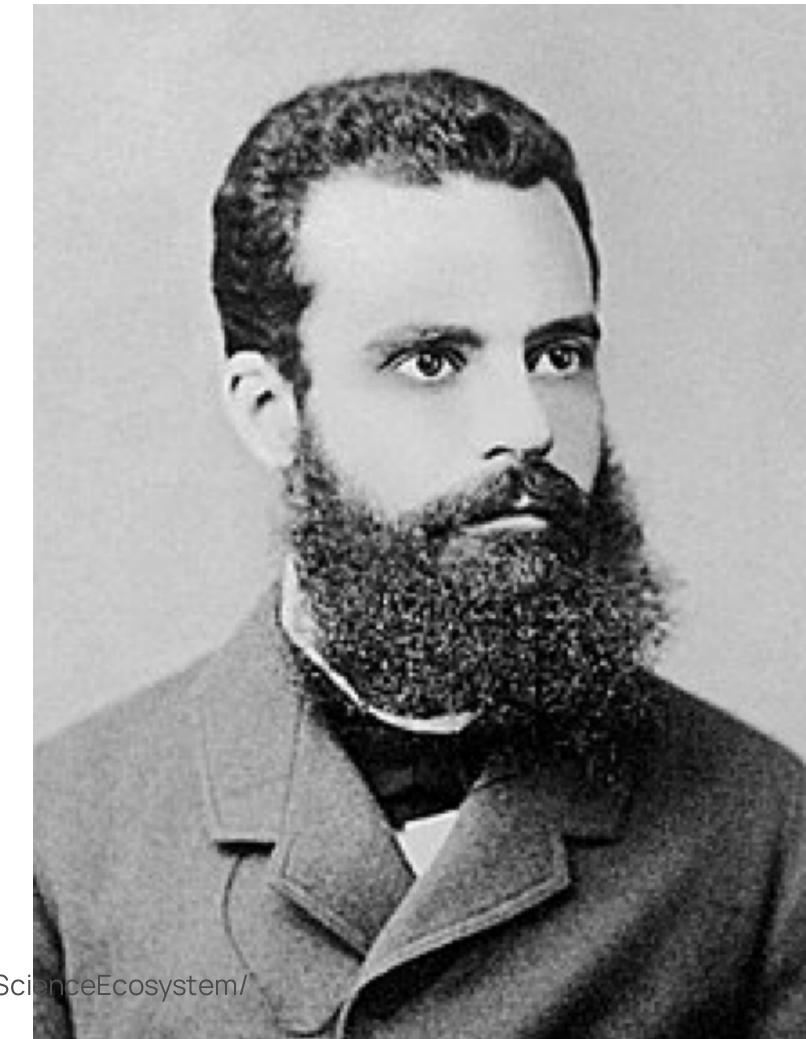
Lessons learned

- Keep it simple and as close to standard practice as possible
 - Overengineered solutions have generally failed
 - If there are more than 2 acronyms...



Lessons learned

- Don't let the perfect be the enemy of the good
 - 20% of the effort will cover 80% of the datasets - focus on these!
 - There is a long tail of edge cases with loud advocates



Conclusions

- The field of neuroimaging has built an model ecosystem for open science and data sharing
- Infrastructure is critical to ease friction
- Community engagement has been key to adoption
- Need to keep the tools as close as possible to current practice

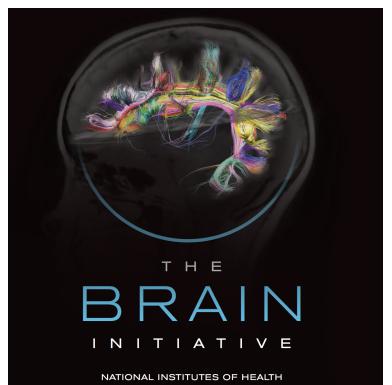
The Poldrack Lab



OpenNeuro Team



Funding

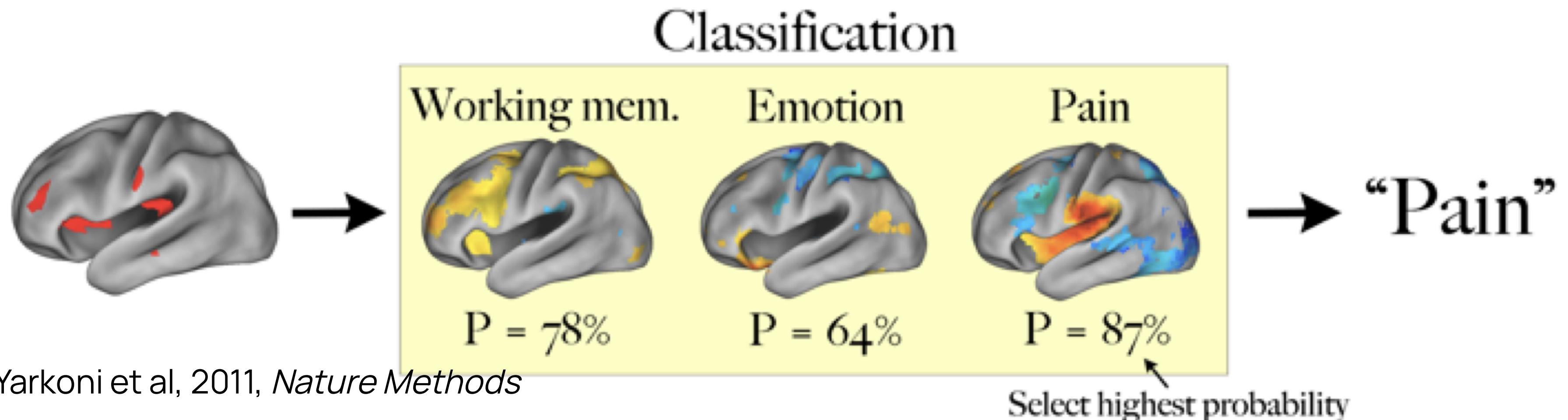


Collaborators



Meta-analytic decoding using Neurosynth

- Given 2+ terms, can determine which is most likely given the data
- Naive Bayes classifier: assumes that all features (voxels) are independent; selects the most probable class
- Can apply this to any activation map—studies, individual subjects, etc.



- Cross-validated classification of all studies in database
 - Select 25 high-frequency terms
 - Pairwise classification: how well can we distinguish between the presence of each pair of terms?
- = Yarkoni et al. 2011, *Nature Methods*

