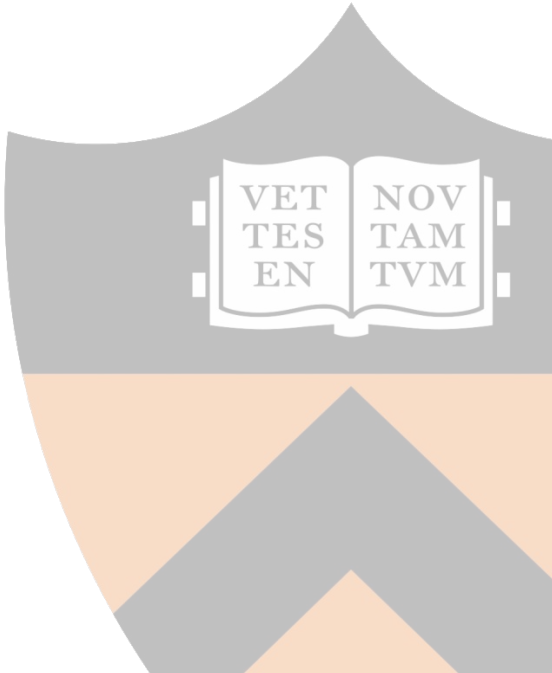
Developing a culture of open, inclusive, community-driven neuroscience

MATLAB Summer 2021

Princeton Neuroscience Institute

July 22, 2021



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Brainhack: developing a culture of open, inclusive, community-driven neuroscience

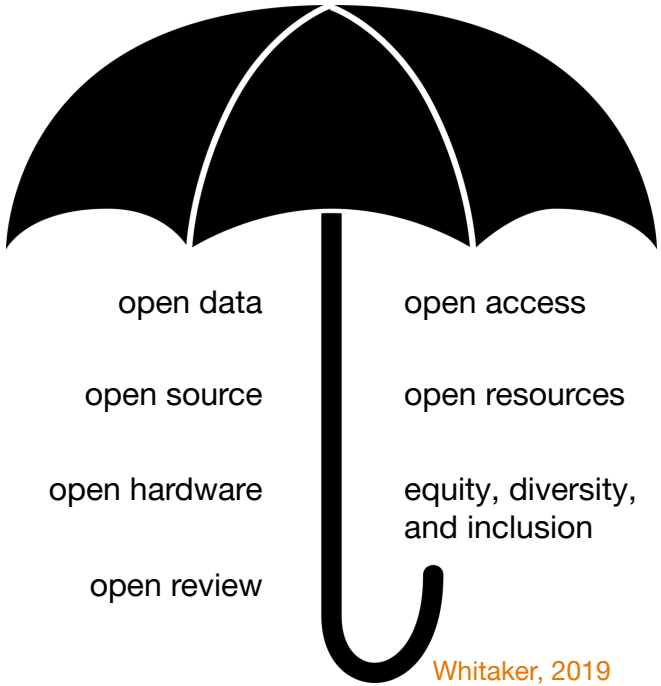
This is a version for community review on psyarxiv and does not constitute the final version of the manuscript.

Rémi Gau[1], Stephanie Noble[2], Katja Heuer[3,4], Katherine L. Bottenhorn[5], Isil P. Bilgin[6,7], Yu-Fang Yang[8], Julia M. Huntenburg[9], Johanna Bayer[10,11], Richard A.I. Bethlehem[12,13], Shawn A. Rhoads[14], Christoph Vogelbacher[15], Valentina Borghesani[16], Elizabeth Levitis[17,18], Hao-Ting Wang[19,20,21], Sofie Van Den Bossche[22], Xenia Kobeleva[23,24], Jon Haitz Legarreta[25], Samuel Guay[26], Selim Melvin Atay[27], Gael P. Varoquaux[28,29], Dorien C. Huijser[30,31], Malin S. Sandström[32], Peer Herholz[33], Samuel A. Nastase[34], AmanPreet Badhwar[35,16,36], Guillaume Dumas[37,38], Simon Schwab[39], Stefano Moia[40,41], Michael Dayan[42], Yasmine Bassil[43], Paula P. Brooks[34], Matteo Mancini[20,44,45], James M. Shine[46], David O'Connor[47], Xihe Xie[48], Davide Poggiali[49], Patrick Friedrich[50], Lydia Riedl[51], Roberto Toro[52,53], Anibal S. Heinsfeld[54,55], César Caballero-Gaudes[40], Anders Eklund[56,57,58], Kelly G. Garner[59,60,61], Christopher R. Nolan[62], Damion V. Demeter[63], Fernando A. Barrios[64], Junaid S. Merchant[65,66], Elizabeth A. McDevitt[34], Robert Oostenveld[67,68], R. Cameron Craddock[69], Ariel Rokem[70], Andrew Doyle[71], Satrajit S. Ghosh[72,73], Aki Nikolaidis[74], Olivia W. Stanley[75,76], Eneko Uruñuela[40,41], The Brainhack Community

Gau et al., *PsyArXiv*, 2021

Open science

Open science means different things to different people—your definition of open science might be different from mine (and that's okay!).



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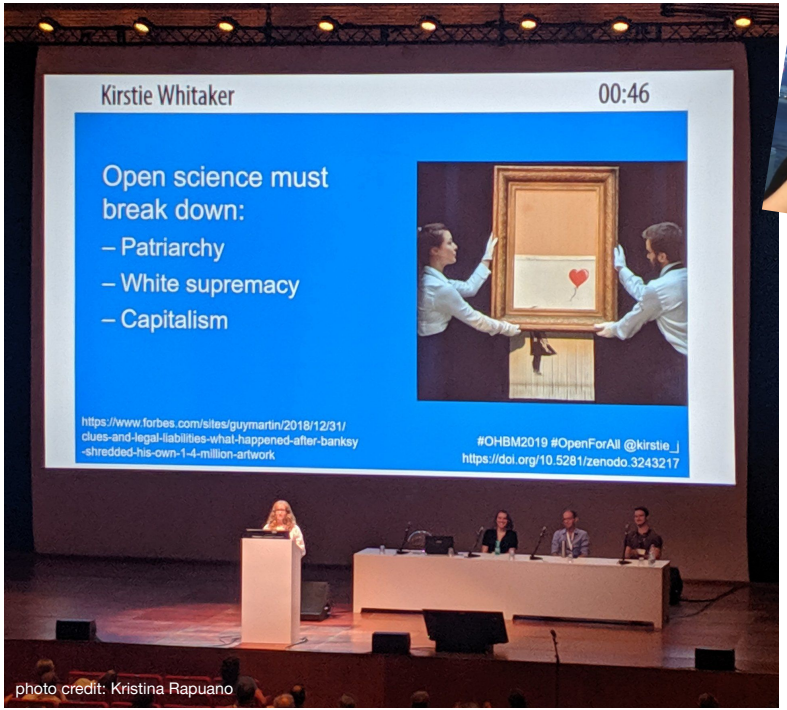
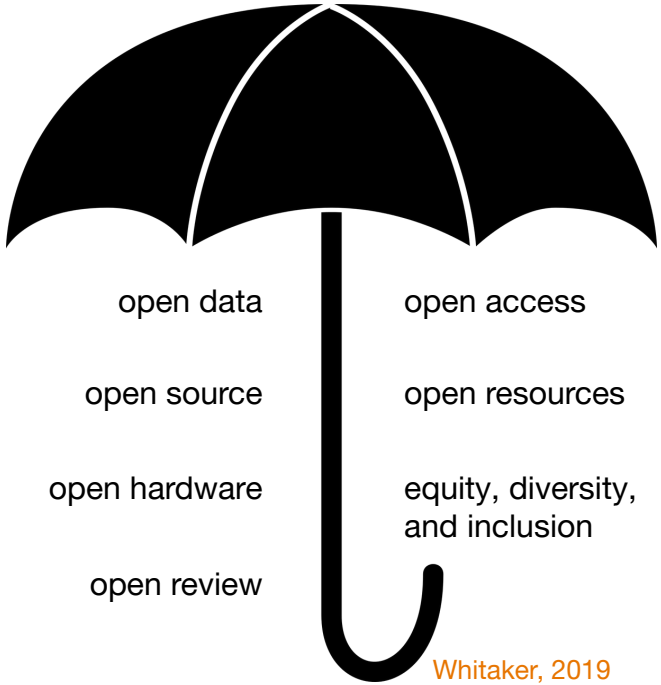


photo credit: Kristina Rapuano



Whitaker, 2019

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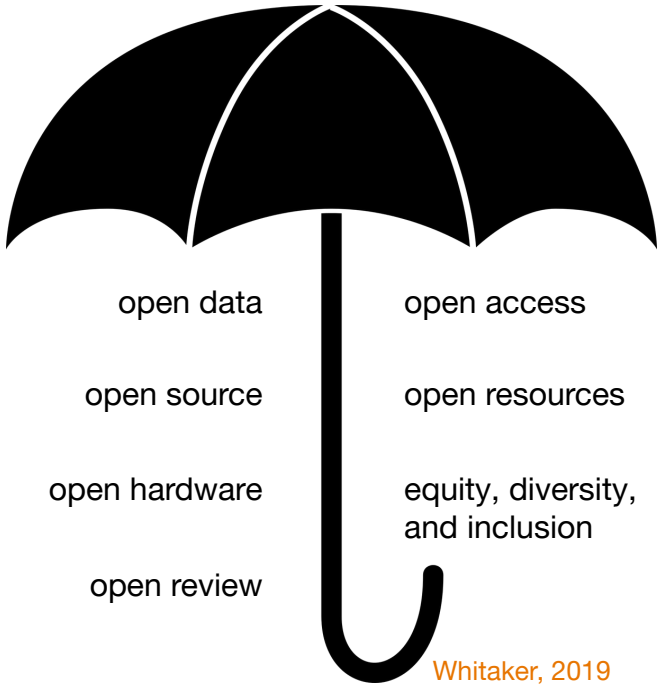
Open science is not all-or-nothing—you shouldn't feel pressured to adopt "all" open science practices at once, and you shouldn't feel inadequate if you haven't learned a particular practice yet.



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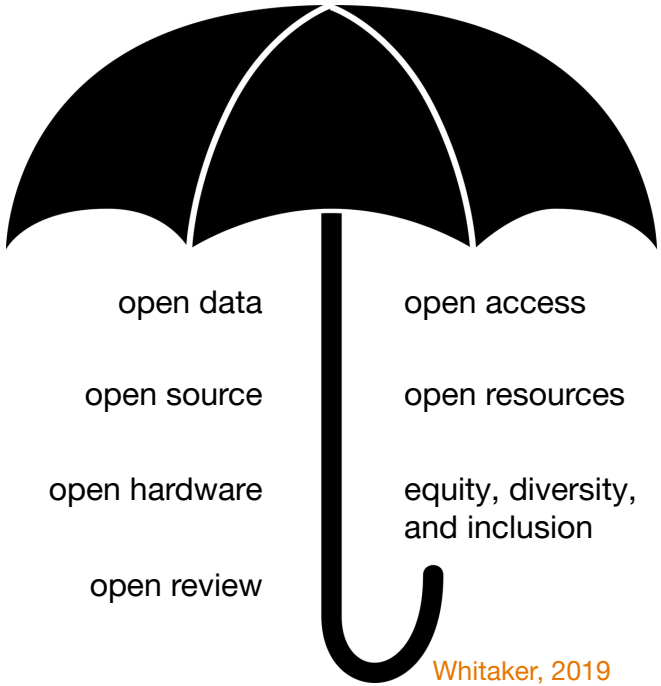
Our working definition: **open science** is the pursuit of a more reproducible, transparent, ethical, inclusive, and collaborative science.



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Topics for today's class:

—version control

—licensing

—data management

—computing environments

—code quality and testing

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Open science

Who benefits from open science?

—you! (your future self will thank you)

—your collaborators (trying to reproduce your results)

—scientists you've never met (using your shared data)

—the public (trusts a more reproducible science)

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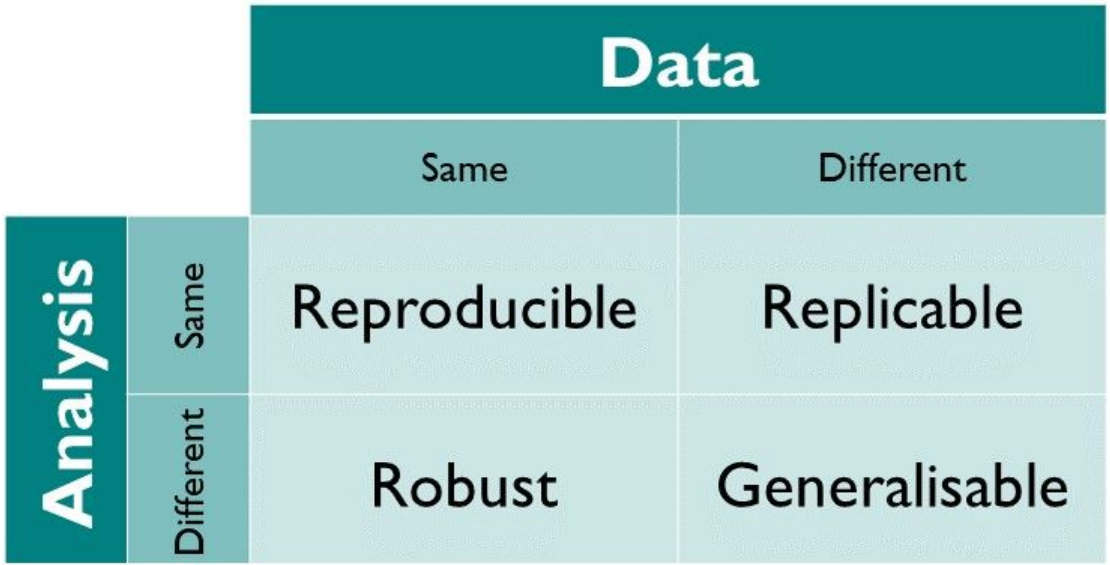

Version control

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We'll focus on content tracking with **Git** (and **GitHub**):

—creating a git repository: **`git init`**

—saving changes to our code: **`git add`** and **`git commit`**

—tracking the history and state of our code: **`git log`** and **`git status`**

—navigating versions and branches: **`git diff`**, **`git checkout`**, and more

—interacting with remote repositories on GitHub: **`git clone`**, **`git pull`**, and **`git push`**

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Version control is a critical component of **open science** because it enhances **reproducibility**, **transparency**, and **accountability**, as well as facilitating **code sharing** and **collaboration**.

Licensing

Licensing governs how others interact with and (re)use your software (and data).

—**proprietary** software is *not free* and is subject to usage restrictions

—**free** software is open source, modifiable, and can be redistributed (e.g. MIT License)

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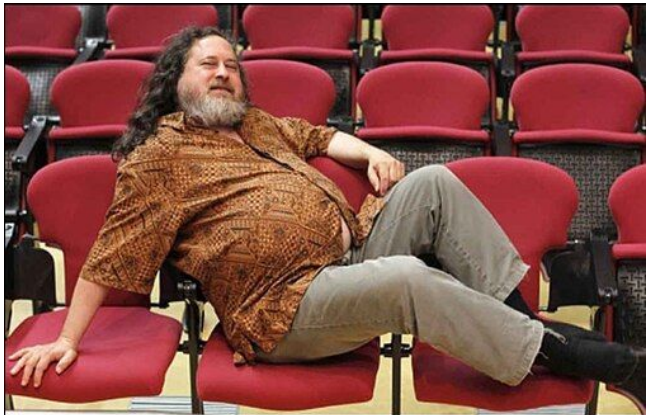

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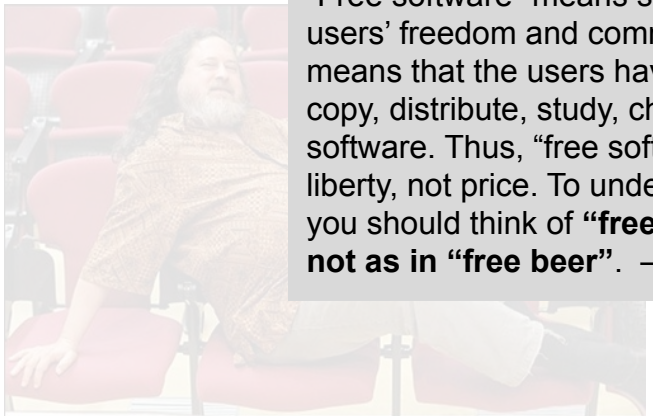

> “Free software” means software that respects users’ freedom and community. Roughly, it means that the users have the freedom to run, copy, distribute, study, change and improve the software. Thus, “free software” is a matter of liberty, not price. To understand the concept, you should think of **“free” as in “free speech,” not as in “free beer”**. —**GNU**

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choosealicense.com

I need to work in a community.

Use the **license preferred by the community** you're contributing to or depending on. Your project will fit right in.

If you have a dependency that doesn't have a license, ask its maintainers to **add a license.**

I want it simple and permissive.

The **MIT License** is short and to the point. It lets people do almost anything they want with your project, like making and distributing closed source versions.

Babel, **.NET Core**, and **Rails** use the MIT License.

I care about sharing improvements.

The **GNU GPLv3** also lets people do almost anything they want with your project, *except* distributing closed source versions.

Ansible, **Bash**, and **GIMP** use the GNU GPLv3.

Data management

Open data relies on **data standardization** and **sharing**—provision for data sharing from the start, not as an afterthought!

—most scientific data collection is publicly funded

—many journals and funding agencies require data sharing

—data sharing saves the public billions of dollars

—public, well-curated benchmark datasets accelerate research

—however, we must take into consideration **consent** and **anonymization**

Wilkinson et al, *Sci Data*, 2016
Milham et al, *Nat Commun*, 2018

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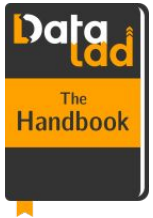
Version control for data using **DataLad**



datalad.org — discover
github.com/datalad/datalad — contribute
handbook.datalad.org — learn

Wagner et al, *Zenodo*, 2020

Review article

Michael Hanke*, Franco Pestilli, Adina S. Wagner, Christopher J. Markiewicz, Jean-Baptiste Poline and Yaroslav O. Halchenko

In defense of decentralized research data management

Brain Imaging Data Structure (BIDS)

What is BIDS?

—a standard for organizing neuroimaging data that facilitates **re-use** and **automated processing**

—the standard specifies machine-readable directory structure, filenames, file formats, and metadata

—consensus-based community-driven development capitalizing on existing conventions

—emphasis on simplicity, readability, and accessibility, i.e. ease of use and adoption

—developed out of the OpenfMRI (now **OpenNeuro**) open neuroimaging data repository

Gorgolewski et al, *Sci Data*, 2016

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What's the point?

—have you ever tried to re-analyze someone else's data?

—have you ever tried to re-analyze *your own data* a year later? (¬_¬)

—have you ever felt *confident* in data you didn't collect yourself?

2016: "To date there has been no consensus about how to organize and share [neuroimaging] data, leading researchers, even those working within the same lab, to arrange their data in different and idiosyncratic ways. Lack of consensus leads to misunderstanding and time wasted on rearranging data or rewriting scripts that expect particular file formats and organization, as well as a possible cause for errors."

Gorgolewski et al, *Sci Data*, 2016

Brain Imaging Data Structure (BIDS)

SCIENTIFIC DATA

OPEN

SUBJECT CATEGORIES
» Data publication and archiving
» Research data

The brain imaging data structure, a format for organizing and describing outputs of neuroimaging experiments

Krzysztof J. Gorgolewski[1], Tibor Auer[2], Vince D. Calhoun[3,4], R. Cameron Craddock[5,6], Samir Das[7], Eugene P. Duff[8], Guillaume Flandin[9], Satrajit S. Ghosh[10,11], Tristan Glatard[7,12], Yaroslav O. Halchenko[13], Daniel A. Handwerker[14], Michael Hanke[15,16], David Keator[17], Xiangrui Li[18], Zachary Michael[19], Camille Maumet[20], B. Nolan Nichols[21,22], Thomas E. Nichols[20,23], John Pellman[6], Jean-Baptiste Poline[24], Ariel Rokem[25], Gunnar Schaefer[1,26], Vanessa Sochat[27], William Triplett[1], Jessica A. Turner[3,28], Gaël Varoquaux[29] & Russell A. Poldrack[1]

Received: 18 December 2015
Accepted: 19 May 2016
Published: 21 June 2016

Brain Imaging Data Structure (BIDS)

SCIENTIFIC DATA

OPEN SCIENTIFIC DATA

SUBJECT CATEGORIES
» Data publication and archiving
» Research data

Received: 18 December 2015
Accepted: 19 May 2016
Published: 21 June 2016

OPEN

Comment: MEG-BIDS, the brain imaging data structure extended to magnetoencephalography

Guiomar Niso[1,2], Krzysztof J. Gorgolewski[3], Elizabeth Bock[1], Teon L. Brooks[3], Guillaume Flandin[4], Alexandre Gramfort[5,6], Richard N. Henson[7], Mainak Jas[5], Vladimir Litvak[4], Jeremy T. Moreau[1], Robert Oostenveld[8,9], Jan-Mathijs Schoffelen[8], Francois Tadel[1,10,11], Joseph Wexler[3] & Sylvain Baillet[1]

Received: 14 November 2017
Accepted: 3 May 2018
Published: 19 June 2018

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Received: 14 November 2017
Accepted: 3 May 2018
Published: 19 June 2018

SCIENTIFIC DATA

OPEN

COMMENT

Received: 16 January 2019
Accepted: 7 May 2019
Published online: 25 June 2019

EEG-BIDS, an extension to the brain imaging data structure for electroencephalography

Cyril R. Pernet[1], Stefan Appelhoff[2], Krzysztof J. Gorgolewski[3], Guillaume Flandin[4], Christophe Phillips[5], Arnaud Delorme[6,7] & Robert Oostenveld[8,9]

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Received: 14 November 2017
Accepted: 3 May 2018
Published: 19 June 2018

SCIENTIFIC DATA

OPEN

COMMENT

Received: 16 January 2019
Accepted: 7 May 2019
Published online: 25 June 2019

SCIENTIFIC DATA

OPEN

COMMENT

Received: 29 January 2019
Accepted: 24 May 2019
Published online: 25 June 2019

iEEG-BIDS, extending the Brain Imaging Data Structure specification to human intracranial electrophysiology

Christopher Holdgraf[1,16], Stefan Appelhoff[2], Stephan Bickel[3], Kristofer Bouchard[4], Sasha D'Ambrosio[5], Olivier David[6], Orrin Devinsky[7], Benjamin Dichter[8], Adeen Flinker[7], Brett L. Foster[9], Krzysztof J. Gorgolewski[8], Iris Groen[10], David Groppe[11], Aysegul Gunduz[12], Liberty Hamilton[13], Christopher J. Honey[14], Mainak Jas[15], Robert Knight[16], Jean-Philippe Lachaux[17], Jonathan C. Lau[18], Christopher Lee-Messer[8], Brian N. Lundstrom[19], Kai J. Miller[20], Jeffrey G. Ojemann[21], Robert Oostenveld[22], Natalia Petridou[23], Gio Piantoni[24], Andrea Pigorini[5], Nader Pouratian[25], Nick F. Ramsey[24], Arjen Stolk[16], Nicole C. Swann[26], François Tadel[6,27], Bradley Voytek[28], Brian A. Wandell[8], Jonathan Winawer[10], Kirstie Whitaker[29,32], Lyuba Zehl[30] & Dora Hermes[8,24,31]

Converting data to BIDS

The hard way...

There are many tools that can facilitate BIDS conversion: **HeuDiConv**, **dcm2niix**, **PyBIDS**, **bidsify**, **bidskit**, **pyBIDSconv**, **dcm2BIDS**, etc.

This is the most unpleasant part…
a single-use script manually tailored to the idiosyncrasies of each data set (☉_◎)

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The easy way!

Using a prespecified naming convention when creating program cards on the scanner console can allow for automated BIDS conversion—e.g. **ReproIn** (for Siemens).

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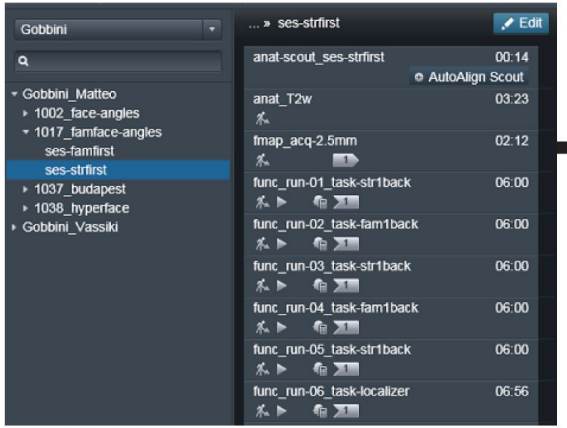
Scanner



DICOM

```
001-anat-scout_ses-strfirst
005-anat_T2w
  000001.dcm
  000002.dcm
  ...
006-fmap_acq-2.5mm
007-fmap_acq-2.5mm
008-func_run-01_task-str1back
011-func_run-01_task-str1back
018-func_run-02_task-fam1back
025-func_run-03_task-str1back
032-func_run-04_task-fam1back
039-func_run-05_task-str1back
046-func_run-06_task-localizer
```

$ heudiconv

Datalad

BIDS

```
anat
  sub-sid000005_ses-strfirst_T2w.json
  sub-sid000005_ses-strfirst_T2w.nii.gz
fmap
  sub-sid000005_ses-strfirst_acq-25mm_magnitude1.json
  sub-sid000005_ses-strfirst_acq-25mm_magnitude1.nii.gz
  ...
func
  sub-sid000005_ses-strfirst_task-fam1back_run-02_bold.json
  sub-sid000005_ses-strfirst_task-fam1back_run-02_bold.nii.gz
  sub-sid000005_ses-strfirst_task-fam1back_run-02_events.tsv
  ...
sub-sid000005_ses-strfirst_scans.tsv
```

```
$ git grep TODO

CHANGES:TODOs:
README:TODO: Provide description for the dataset ...
dataset_description.json: "Acknowledgements": "TODO...",
dataset_description.json:   "TODO:",
dataset_description.json: "DatasetDOI": "TODO: ...
task-fam1back_bold.json:  "CogAtlasID": "TODO",
task-fam1back_bold.json:  "TaskName": "TODO: full task name",
task-localizer_bold.json:  "CogAtlasID": "TODO",
task-localizer_bold.json:  "TaskName": "TODO: full task name",
task-str1back_bold.json:  "CogAtlasID": "TODO",
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Visconti di Oleggio Castello et al, *Zenodo*, 2020

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Moral of the story:
standardize for sharing from the start and not as an afterthought (๑>ᴗ<)ง

Halchenko & Hanke, *GigaScience*, 2015

CHANGES
README
code
dataset_description.json
derivatives
participants.json
participants.tsv
stimuli
sub-001
sub-002
sub-003
sub-004
sub-005
sub-006
sub-007
sub-008
sub-009
sub-010
sub-011
sub-012
sub-013
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Gorgolewski et al., *Sci Data*, 2016

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

Neural responses to naturalistic clips of behaving animals in two different task contexts

EDIT

uploaded by Sam Nastase on 2017-09-23 - over 3 years ago
last modified on 2019-12-14 - about 1 year ago
authored by Samuel A. Nastase, Yaroslav O. Halchenko, Andrew C. Connolly, M. Ida Gobbini, James V. Haxby
154 41939

Download Analyze on brainlife.io

OpenNeuro Accession Number: ds000233
Files: 455, **Size:** 4.05GB, **Subjects:** 12, **Session:** 1
Available Tasks: beh, tax
Available Modalities: T1w, defacemask, bold, events

Nastase et al, *Front Neurosci*, 2017

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

Neural responses to naturalistic clips of behaving animals in two different task contexts

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Available Tasks: beh, tax
Available Modalities: T1w, defacemask, bold, events

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

CHANGES

```
1.0.3   2018-05-02

  - Shared stimuli, updated *_events.tsv files, updated references

1.0.2   2018-04-12

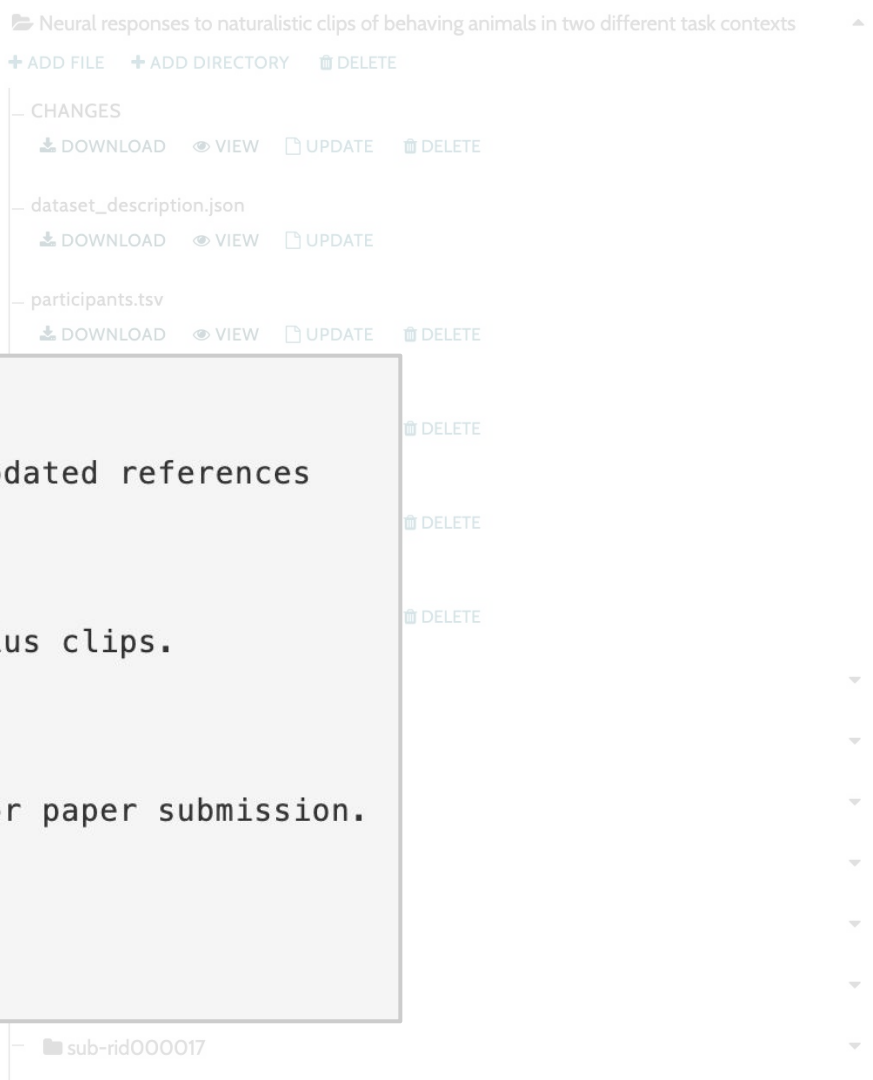
  - Updated for paper revision; now sharing stimulus clips.

1.0.1   2018-02-20

  - Contains code, derivatives; for data descriptor paper submission.

1.0.0   2017-07-24

  - Initial release.
```



Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

README

```
Source data (sourcedata/) may contain sensitive information and
therefore not distributed publicly. The 40 video clip stimuli
(MPEG-4 files) are distributed alongside the data in keeping with
fair use provisions for non-commercial scholarly research (see
stimuli/README.md for more information).

Note that in constructing the trial order for one run (sub-
rid0000*_task-beh_run-1_bold.nii.gz) an unintended collision
occurred where a behavior repetition event interrupted a taxonomic
repetition event. This means that one less taxonomic category
repetition occurred in this run (3 in stead of 4), and the stimulus
bird_eating_1.mp4 occurred 3 times instead of the intended 2 times
in this run.
```

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

participants.tsv

participant_id	age	sex	group
sub-rid000001	24	m	control
sub-rid000012	24	f	control
sub-rid000017	24	m	control
sub-rid000024	24	f	control
sub-rid000027	25	m	control
sub-rid000031	28	f	control
sub-rid000032	24	f	control
sub-rid000033	26	m	control
sub-rid000034	28	f	control
sub-rid000036	26	f	control
sub-rid000037	31	m	control
sub-rid000041	21	f	control

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

`dataset_description.json`


```
{
    "Acknowledgements": "We thank Jason Gors, Kelsey G. Wheel
er J. Swaroop Guntupalli, Matteo Visconti di Oleggio Castell
o, M. Ida Gobbini, Terry Sacket, and the rest of the DBIC (Da
rtmouth Brain Imaging Center) personnel for assistance in dat
a collection/curation.",
    "Authors": [
        "Samuel A. Nastase",
        "Yaroslav O. Halchenko",
        "Andrew C. Connolly",
        "M. Ida Gobbini",
        "James V. Haxby"
    ],
    "BIDSVersion": "1.0.2",
    "DatasetDOI": "10.18112/openneuro.ds000233.v1.0.1",
    "Funding": [
        "5R01MH075706",
        "F32MH085433-01A1",
        "NSF1129764",
        "NSF1607845"
    ],
```

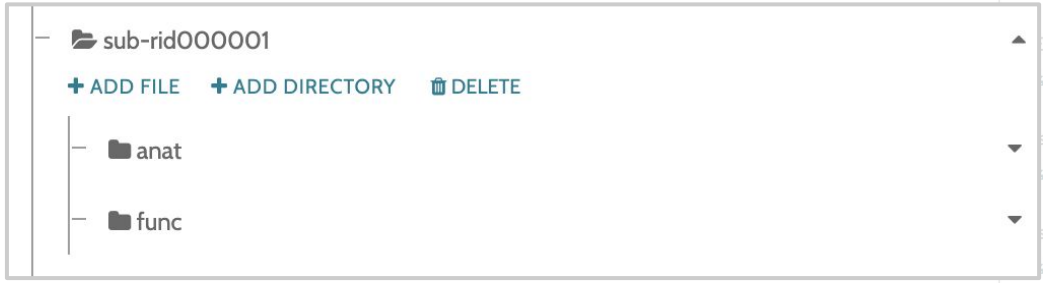
Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

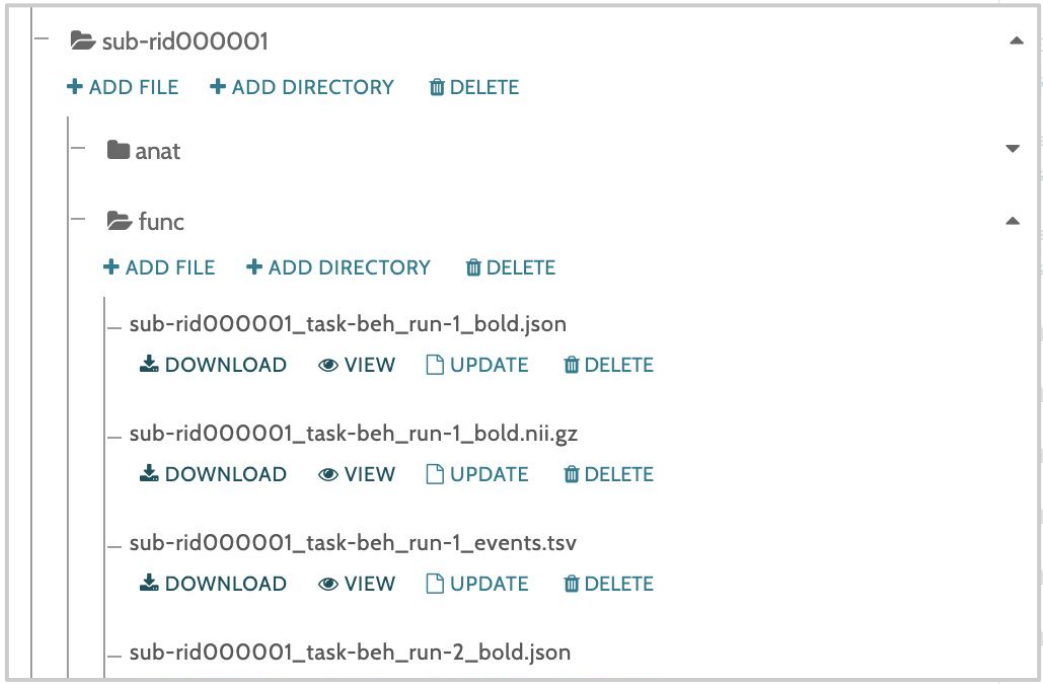
`sub-rid000001/`



Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

`sub-rid000001/func/`

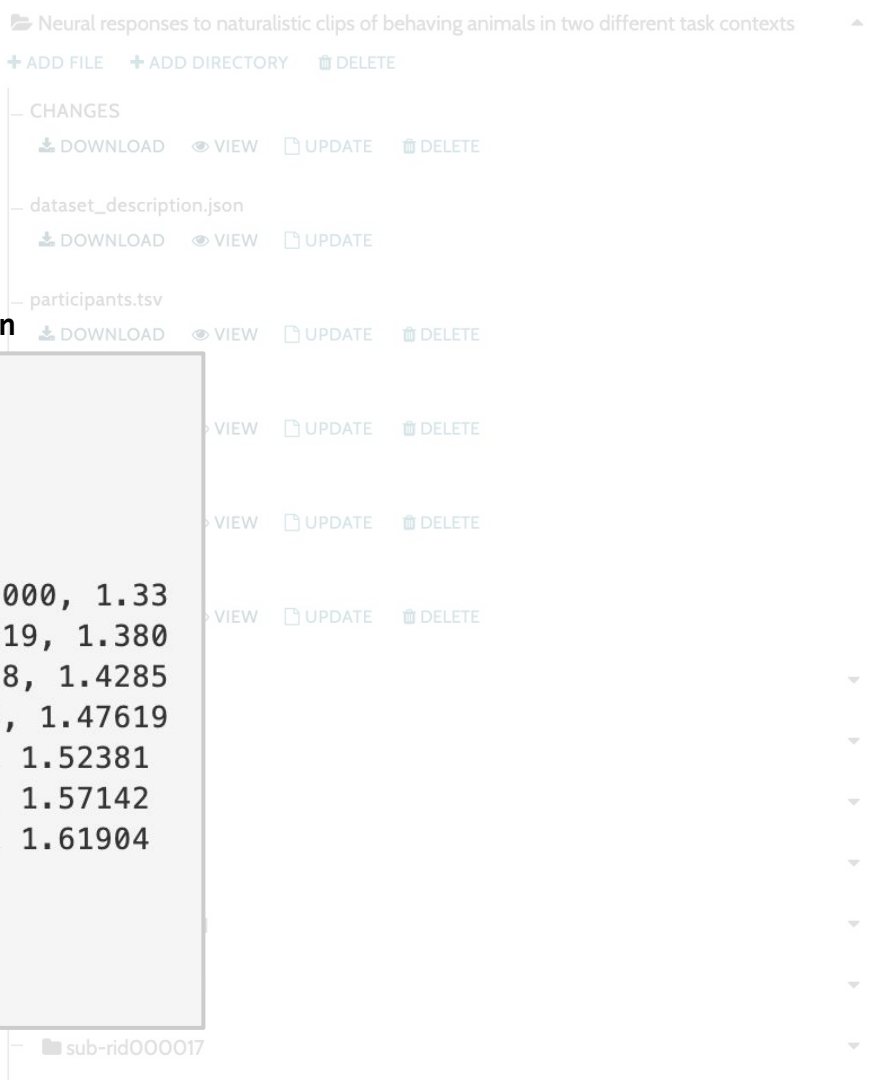


Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

sub-rid000001/func/sub-rid000001_task-beh_run-1_bold.json


```
{
 "RepetitionTime": 2.0,
 "TaskName": "beh",
 "EchoTime": 0.035,
 "FlipAngle": 90,
 "SliceTiming": [0.000000, 0.333333, 0.666667, 1.000000, 1.33
3333, 1.666667, 0.047619, 0.380952, 0.714286, 1.047619, 1.380
952, 1.714286, 0.095238, 0.428571, 0.761905, 1.095238, 1.4285
71, 1.761905, 0.142857, 0.476190, 0.809524, 1.142857, 1.47619
0, 1.809524, 0.190476, 0.523810, 0.857143, 1.190476, 1.52381
0, 1.857143, 0.238095, 0.571429, 0.904762, 1.238095, 1.57142
9, 1.904762, 0.285714, 0.619048, 0.952381, 1.285714, 1.61904
8, 1.952381],
 "ParallelReductionFactorInPlane": 2,
 "ParellelReductionType": "SENSE",
 "Manufacturer": "Philips",
```

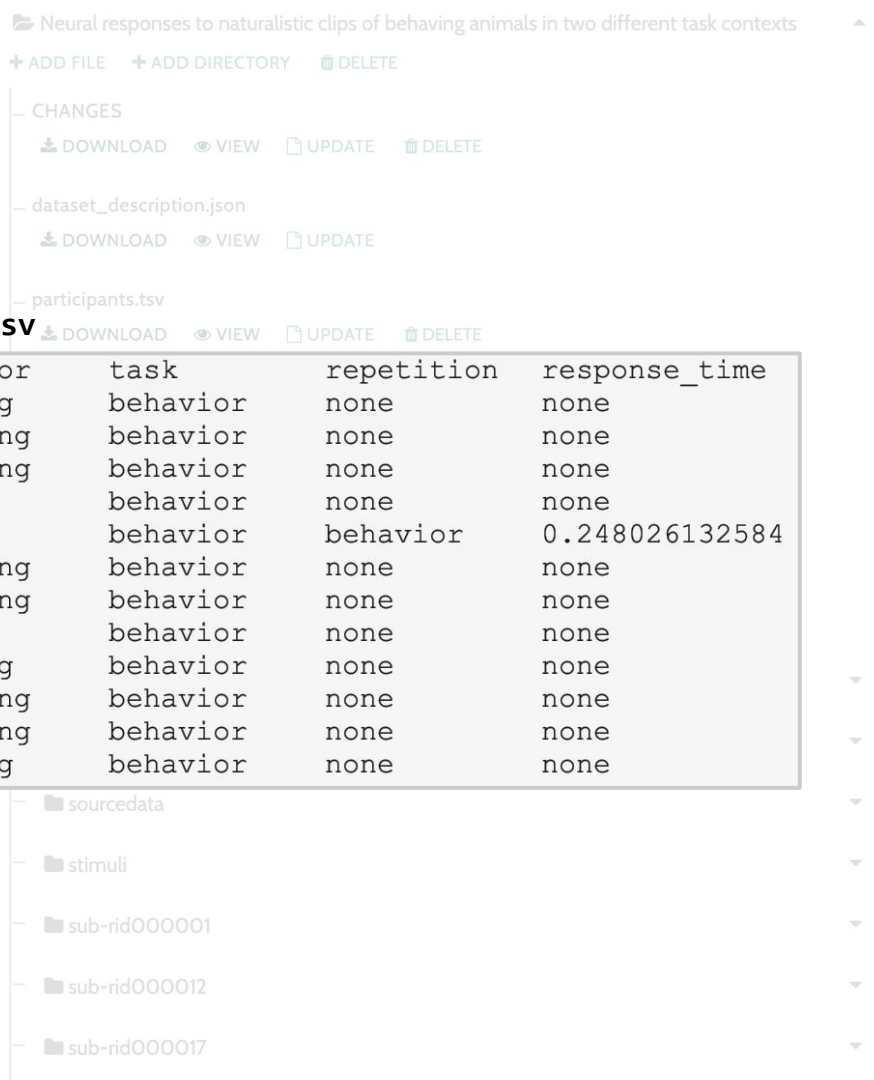



Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

sub-rid000001/func/sub-rid000001_task-beh_run-1_events.tsv

onset	duration	trial_type	taxonomy	behavior	task	repetition	response_time
12.0	2.0	ungulate_running	ungulate	running	behavior	none	none
16.0	2.0	bird_fighting	bird	fighting	behavior	none	none
20.0	2.0	insect_swimming	insect	swimming	behavior	none	none
28.0	2.0	bird_eating	bird	eating	behavior	none	none
32.0	2.0	ungulate_eating	ungulate	eating	behavior	behavior	0.248026132584
36.0	2.0	primate_fighting	primate	fighting	behavior	none	none
40.0	2.0	bird_swimming	bird	swimming	behavior	none	none
44.0	2.0	ungulate_eating	ungulate	eating	behavior	none	none
48.0	2.0	bird_running	bird	running	behavior	none	none
52.0	2.0	reptile_swimming	reptile	swimming	behavior	none	none
56.0	2.0	insect_fighting	insect	fighting	behavior	none	none
60.0	2.0	primate_running	primate	running	behavior	none	none



Brain Imaging Data Structure (BIDS)

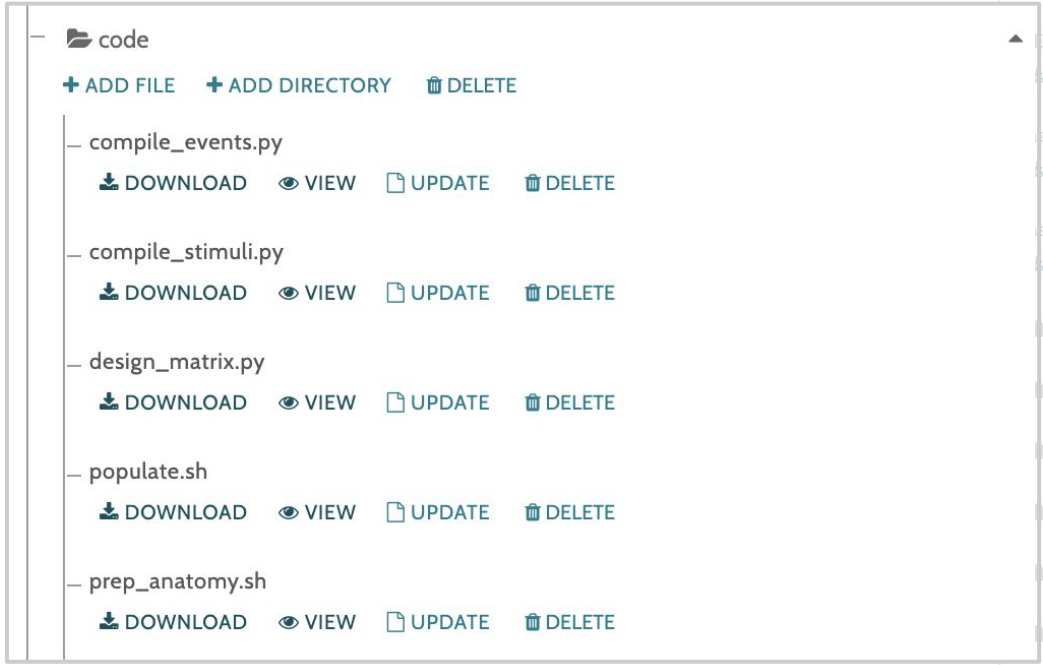
Example: OpenNeuro ds000233

`derivatives/`

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

code/



Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

`stimuli/`

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

`stimuli/`

stimuli

+ ADD FILE + ADD DIRECTORY DELETE

bird_eating_1.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_eating_2.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_fighting_1.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_fighting_2.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_running_1.mp4
DOWNLOAD VIEW UPDATE DELETE

Brain Imaging Data Structure (BIDS)

Example: OpenNeuro ds000233

`stimuli/`

stimuli

+ ADD FILE + ADD DIRECTORY DELETE

bird_eating_1.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_eating_2.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_fighting_1.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_fighting_2.mp4
DOWNLOAD VIEW UPDATE DELETE

bird_running_1.mp4
DOWNLOAD VIEW UPDATE DELETE

Neural responses to naturalistic clips of behaving animals in two different task contexts

+ ADD FILE + ADD DIRECTORY DELETE

CHANGES

DOWNLOAD VIEW UPDATE DELETE

sub-rid000017

Brain Imaging Data Structure (BIDS)

What is BIDS?

—a standard for organizing neuroimaging data that facilitates **re-use** and **automated processing**

—the standard specifies machine-readable directory structure, filenames, file formats, and metadata

—consensus-based community-driven development capitalizing on existing conventions

—emphasis on simplicity, readability, and accessibility, i.e. ease of use and adoption

—developed out of the **OpenfMRI** (now **OpenNeuro**) open neuroimaging data repository

The importance of automated processing

Neuroimaging analysis is complex and flexible—relying on multi-stage processing workflows with many possible analysis choices at each stage (i.e. “researcher degrees of freedom”).

The machine-readable BIDS organization with rich metadata allows for adaptive, automated processing and analysis (i.e. BIDS Apps) that:

—minimize error-prone manual intervention and “procedural overfitting”

—maximize reproducible execution via containerization and content-tracking

Carp, *Front Neurosci*, 2012
Ghosh et al, *F1000Research*, 2017
Botvinik-Nezer et al, *Nature*, 2020

PLOS COMPUTATIONAL BIOLOGY

RESEARCH ARTICLE

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

Krzysztof J. Gorgolewski[1]*, Fidel Alfaro-Almagro[2], Tibor Auer[3], Pierre Bellec[4,5], Mihai Capotă[6], M. Mallar Chakravarty[7,8], Nathan W. Churchill[9], Alexander Li Cohen[10], R. Cameron Craddock[11,12], Gabriel A. Devenyi[7,8], Anders Eklund[13,14,15], Oscar Esteban[1], Guillaume Flandin[16], Satrajit S. Ghosh[17,18], J. Swaroop Guntupalli[19], Mark Jenkinson[2], Anisha Keshavan[20], Gregory Kiar[21,22], Franziskus Liem[23], Pradeep Reddy Raamana[24,25], David Raffelt[26], Christopher J. Steele[7,8], Pierre-Olivier Quirion[15], Robert E. Smith[26], Stephen C. Strother[24,25], Gaël Varoquaux[27], Yida Wang[6], Tal Yarkoni[28], Russell A. Poldrack[1]

Automated processing and containerization

What is a BIDS App?

—the machine-readable BIDS format enables automated processing via **BIDS Apps**

—BIDS Apps use **containerization** to facilitate portability and reproducibility

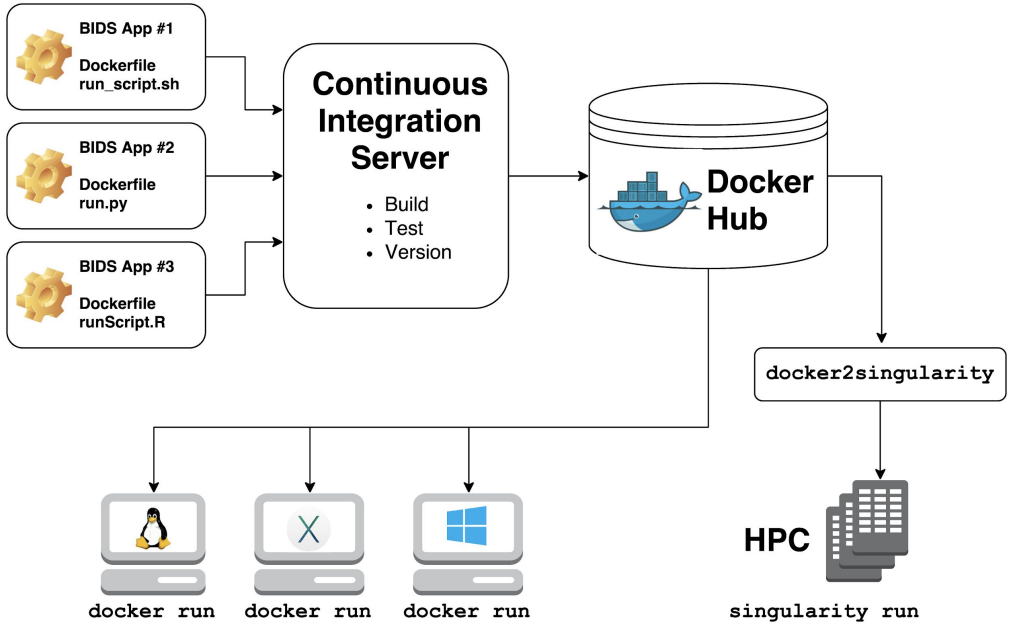
Software containers

Containerization solutions package software with all dependencies in single, encapsulated image.

Docker (for local use)

Singularity (for servers)

Kurtzer et al, *PLOS One*, 2017



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Docker (for local use)

Singularity (for servers)

Kurtzer et al, *PLOS One*, 2017

```
# Define the operating system as Linux
os: linux

# Use the xenial distribution of Linux
dist: xenial

# Use the programming language Python
language: python

# Use version of Python 3.2
python: 3.2

# Use the Python package numpy and use version 1.16.1
packages:
  numpy:
    version: 1.16.1
```

Automated processing and containerization

What is a BIDS App?

—the machine-readable BIDS format enables automated processing via **BIDS Apps**

—BIDS Apps use **containerization** to facilitate portability and reproducibility

Computational environments must be tracked, encapsulated, and portable so other researchers can **reproduce** them.

—pay attention to software versions (**semantic versioning**: `major.minor.patch`)

—pay attention to environment variables (e.g. using `which` and `$PATH`)

—**software distributions** (e.g. **Anaconda**) index and release software

—**package managers** (e.g. **conda**) track software versions and dependencies

Code quality and testing

Write (readable!) code with the goal of **sharing** and **collaboration**.

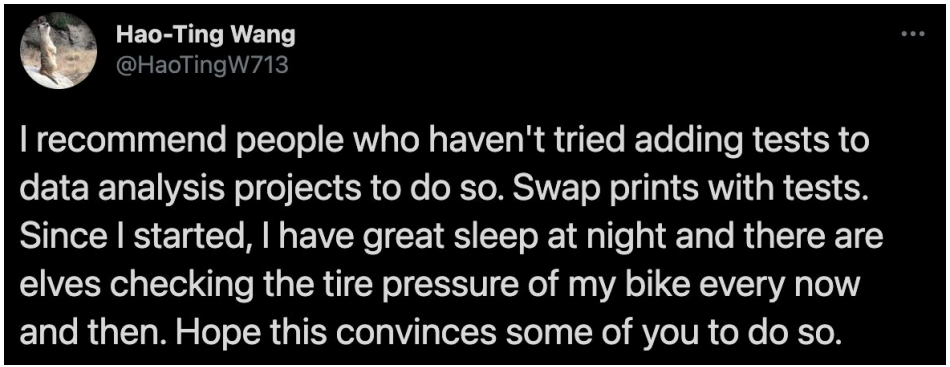
—thorough comments and documentation

—follow community standards (e.g. use a **linter**)

Write **tests** in the process of writing your code and use **continuous integration**.

—fail early, fail often!

—types of types: smoke tests, unit tests, **etc**



Getting started with open data

General considerations
—you want data in a standardized format (e.g. BIDS)
—you want data with rich enough metadata for processing
—you want data with well-described tasks or stimuli

OpenNeuro—BIDS-formatted task fMRI data:
Haxby et al., 2001; Naturalistic Neuroimaging Database; BOLD5000; MyConnectome; Midnight Scan Club; NARPS; Narratives; etc

FCP/INDI—resting-state and translational data:
Healthy Brain Network; ABIDE; ADHD-200; etc

Other big datasets and useful tools:
HCP; Cam-CAN; ABCD; UK-Biobank; Allen Institute; DataLad Data Distribution, Google Dataset Search, Princeton DataSpace (e.g. Sherlock)

ReproNim: A Center for Reproducible Neuroimaging Computation

Everything Matters: The ReproNim Perspective on Reproducible Neuroimaging

David N. Kennedy[1], Sanu A. Abraham[2], Julianna F. Bates[1], Albert Crowley[3], Satrajit Ghosh[2], Tom Gillespie[4], Mathias Goncalves[2], Jeffrey S. Grethe[4], Yaroslav O. Halchenko[5], Michael Hanke[6], Christian Haselgrove[1], Steven M. Hodge[1], Dorota Jarecka[2], Jakub Kaczmarzyk[2], David B. Keator[7], Kyle Meyer[5], Maryann E. Martone[4], Smruti Padhy[2], Jean-Baptiste Poline[8], Nina Preuss[3], Troy Sincomb[4] and Matt Travers[3]*

https://doi.org/10.3389/fninf.2019.00001

NIH-NIBIB P41 EB019936

NEUROHACKADEMY

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SUMMER SCHOOL AND HACKATHON

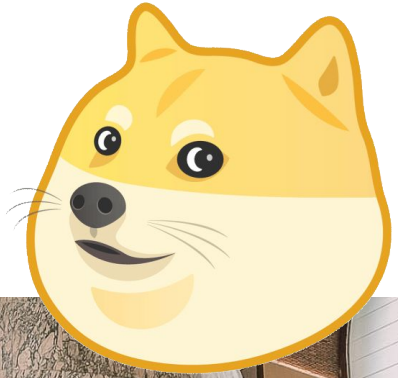
Hack, noun

1. A clever or elegant technical accomplishment, especially one with a playful or prankish bent. A clever routine in a computer program, especially one which uses tools for purposes other than those for which they were intended, might be considered a hack.

2. A temporary, jury-rigged solution, especially in the fields of computer programming and engineering: the technical equivalent of chewing gum and duct tape. Compare to kludge.

#OHBM2019 Hackathon

Mercato Centrale, Roma Termini (and several other random places)



Over 180 people signed up for the hackathon in 2019!

ohbm / hackathon2019

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Code | Issues 62 | Pull requests 1 | Projects 0 | Wiki | Security | Insights

Website and projects for the OHBM Hackathon in Rome 2019 https://ohbm.github.io/hackathon2019

149 commits | 9 branches | 0 releases | 16 contributors

Branch: master | New pull request | Create new file | Upload files | Find File | Clone or download

pbellec Update Tutorial_Resources.md — Latest commit 7c65b3f 8 days ago

bg-img	change background slide 4	2 months ago
img	adding all sponsors	3 months ago
libs	Website initial commit Hackathon 2019	3 months ago
CODE_OF_CONDUCT.md	Create CODE_OF_CONDUCT.md	8 months ago
Issue_Template.md	Update Issue_Template.md	8 months ago
ReadMe.md	Add venues to readme	14 days ago
Tutorial_Resources.md	Update Tutorial_Resources.md	8 days ago
index.html	Update index.html	14 days ago

ReadMe.md

hackathon2019

Website and projects for the OHBM Hackathon in Rome 2019

chat on gitter | Mattermost Join Brainhack's Mattermost

Brainhacks have become part of our way of doing science in a connected world since the time we participated in the first ever Brainhack. By creating a friendly and inclusive environment during 3 days of intense collaborations, they can provide the means to create and strengthen collaborations that can be pursued online the rest of the year.

Brainhacks are the opportunity to try new ideas, to discover new tools, to adopt open science best practices and actively push its boundaries, and to meet the people from all disciplines that are inventing tomorrow's brain mapping.

#OHBM2019 Hackathon

Mercato Centrale, Roma Termini (and several other random places)

PROGRAM

Thursday 6 June 2019

9h	Check-in & breakfast
	Welcome and introduction
9.30h	Ignite talk: "A Brainhack carol.
	The Ghost of Hackathons Past: Pierre Bellec"
10.30h	Project pitches
12h	Lunch
13-20h	Hackathon /
	TrainTrack: Best practices in
	open source development
	TrainTrack: Reproducible Science I
20.30h	Social at Annalemma

Friday 7 June 2019

9h	Breakfast
9.30h	Ignite talk: "A Brainhack carol.
	The Ghost of Hackathon Present: Katie Bottenhorn"
10.30h	Hackathon /
	TrainTrack: Reproducible Science II
12h	Lunch
13-20h	Hackathon

Saturday 8 June 2019

9h	Breakfast
9.30h	Ignite talk: "A Brainhack carol.
	The Ghost of Hackathons Future: Satrajit Ghosh"
10.30h	Hackathon
12h	Lunch
13-20h	Hack & Project summaries

PROGRAM TrainTrack, tentative, see here for live updates!

Session 1: Best practices in open source development
Thursday 13:00 - 16:00 Options include:

13:30-15:00	Intro to Git/GitHub (ReproStaff)
15:00-16:00	Introduction to testing and Continuous Integration
16:00-17:00	Available!

Session 2: Open and Reproducible Science (Part 1)
Thursday 17:00-20:00 Options include:

17:00-18:00	DataLad - Everything you ever wanted to know, but were afraid to ask... (Yarik Halchenko/Satra Ghosh)
18:00-19:00	Containers: Using docker for open & reproducible science - an introduction (Peer Herholz/Dorota Jarecka)
19:00-20:00	Available!

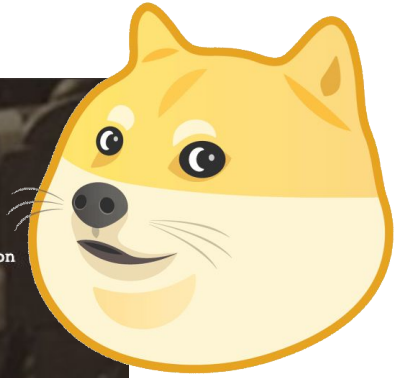
Session 3: Open and Reproducible Science (Part 2)
Location: Palazzo Montemartini (Largo Giovanni Montemartini, 00185 Roma RM)

Friday 10:30 - 15:30. Options include:

10:30-11:30 Interactive Introduction to C-PAC (Anibal Solon)
11:30-12:30 Binder and NeuroLibre! (Loic Tetrel)

Lunch!

13:30-14:30 ReproIn - The ReproNim image input management system (Yarik Halchenko/Satra Ghosh)
14:30-15:30 Teaching an Old BIDS New Tricks - Semantic Markup of BIDS data (David Keator/Jeff Grethe)




Brainhack Princeton 2020
Princeton, NJ, USA
December 9-11, 2020
Register Now
Schedule
Submit a Project
Code of Conduct
Join Princeton Brainhack on Mattermost
Photo by Smallbones

Brainhack: developing a culture of open, inclusive, community-driven neuroscience

This is a version for community review on psyarxiv and does not constitute the final version of the manuscript.

Rémi Gau*[1], Stephanie Noble*[2], Katja Heuer*[3,4], Katherine L. Bottenhorn*[5], Isil P. Bilgin*[6,7], Yu-Fang Yang*[8], Julia M. Huntenburg*[9], Johanna Bayer*[10,11], Richard A.I. Bethlehem*[12,13], Shawn A. Rhoads[14], Christoph Vogelbacher[15], Valentina Borghesani[16], Elizabeth Levitis[17,18], Hao-Ting Wang[19,20,21], Sofie Van Den Bossche[22], Xenia Kobeleva[23,24], Jon Haitz Legarreta[25], Samuel Guay[26], Selim Melvin Atay[27], Gael P. Varoquaux[28,29], Dorien C. Huijser[30,31], Malin S. Sandström[32], Peer Herholz[33], Samuel A. Nastase[34], AmanPreet Badhwar[35,16,36], Guillaume Dumas[37,38], Simon Schwab[39], Stefano Moia[40,41], Michael Dayan[42], Yasmine Bassil[43], Paula P. Brooks[34], Matteo Mancini[20,44,45], James M. Shine[46], David O'Connor[47], Xihe Xie[48], Davide Poggiali[49], Patrick Friedrich[50], Lydia Riedl[51], Roberto Toro[52,53], Anibal S. Heinsfeld[54,55], César Caballero-Gaudes[40], Anders Eklund[56,57,58], Kelly G. Garner[59,60,61], Christopher R. Nolan[62], Damion V. Demeter[63], Fernando A. Barrios[64], Junaid S. Merchant[65,66], Elizabeth A. McDevitt[34], Robert Oostenveld[67,68], R. Cameron Craddock[69], Ariel Rokem[70], Andrew Doyle[71], Satrajit S. Ghosh[72,73], Aki Nikolaidis[74], Olivia W. Stanley[75,76], Eneko Uruñuela[40,41], The Brainhack Community

The Princeton Handbook for Reproducible Neuroimaging

The Princeton Handbook for Reproducible Neuroimaging will provide you with steps and best practices about how to collect and analyze fMRI data.

START HERE
Flowchart about conducting fMRI research

CLICK FOR MATERIALS
FALL 2020 PYGERS WORKSHOP NOTES & RECORDINGS

Important:

Welcome to the Princeton Handbook for Reproducible Neuroimaging! The handbook is currently under active development—expect substantial changes in the near future. The goal of this handbook is to provide a reference for best practices in reproducible fMRI research. There's no single "right" answer for many questions in fMRI, but here we try to provide helpful references and recommendations. Many elements of the handbook are specific to the Princeton Neuroscience Institute computing infrastructure, but the principles are widely applicable. This document will be updated over time as best practices evolve. We hope that this handbook will be useful as you embark on your own journey doing fMRI experiments!

Please contact us if you have any questions, feedback, or suggestions!

Brand new to neuroimaging?

Familiarize yourself with important background reading material here. If you're unsure about any terms, check out the glossary.

Brooks et al, *Zenodo*, 2021

The Cathedral and the Bazaar

“The history of Unix should have prepared us for what we’re learning from Linux. That is, while coding remains an essentially solitary activity, the really great hacks come from harnessing the attention and brainpower of entire communities. The developer who uses only his or her own brain in a closed project is going to fall behind the developer who knows how to create an open, evolutionary context in which feedback exploring the design space, code contributions, bug-spotting, and other improvements come from from hundreds (perhaps thousands) of people.”

Raymond, 1999

The Cathedral and the Bazaar

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If you like MATLAB, you would *love*...
- —**Python!**
- —**R**
- —**Julia**
- —and many more

—Is MATLAB free?

—Is MATLAB open source?

—Is MATLAB community-driven?

I Hate Matlab: How an IDE, a Language, and a Mentality Harm, by Olivia Guest

Raymond, 1999

Thanks for listening!