



Open science: a dynamic ecosystem

Gaëlle Leroux

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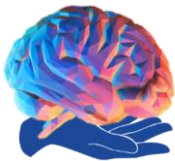
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Open Science: a dynamic ecosystem



Methodological
support
for imaging
projects

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Research engineer

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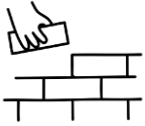
 <https://orcid.org/0000-0003-2729-4945>



Why open up the science?

- ➔ **to open up the results of science** (publications, research data where possible)
- ➔ **but also a new way of doing research.**

This involves opening up processes, codes, methods and protocols.



It comes from a movement to **contest the monopoly position of the major publishers by promoting open access.**

Source: translation of a [Couperin Guide](#)

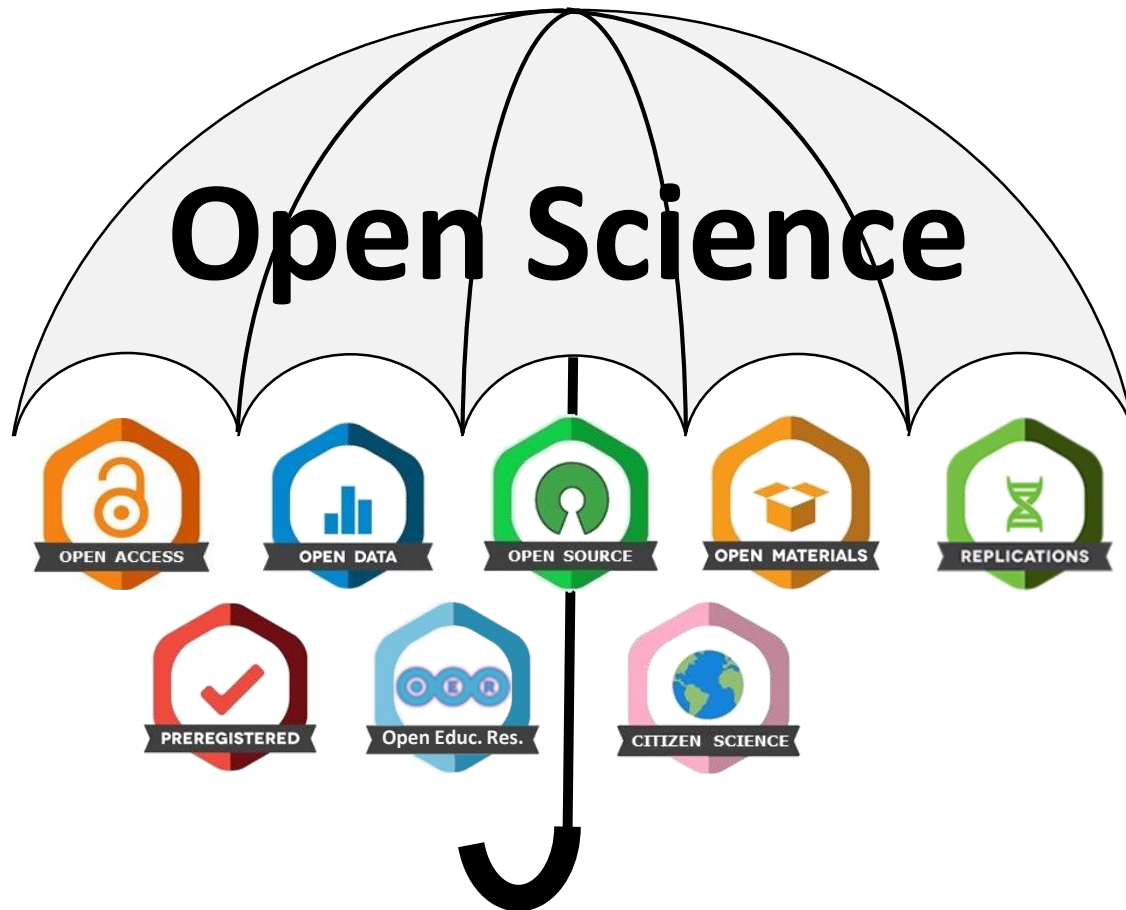


“Open science is a movement that aims to **involve new stakeholders, such as everyday citizens and non-research organisations**, in the research process, and to **make the products of research** — everything from scientific publications and data to software programs — **more accessible and reusable for the scientific community and for society at large.**”

Sharing research findings not only with other researchers but with society is **the best way to advance knowledge** and **build trustworthy relationships with multiple stakeholders.**”

Source: [INRAE committed to open science](#)

Image credits: icons made by Dooder www.flaticon.com & Bonazzi/Salzmanart (2022) *Science*. doi:10.1126/science.adf4323



The Open Science “umbrella” with [Open Science Foundation](#) badges (adapted).
These are not the only terms under the umbrella

Adapted from an [academic blog of Vu Univ., NL](#)

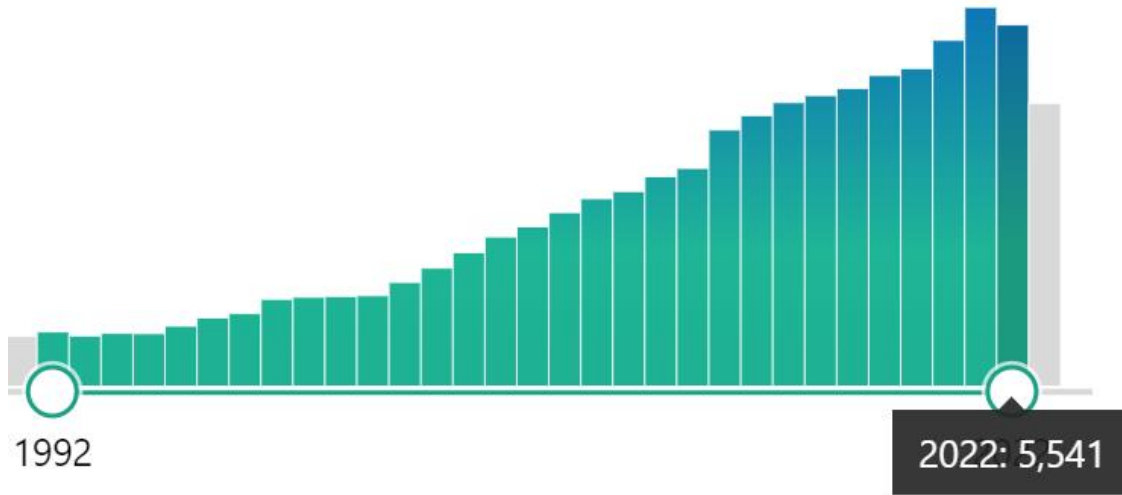


The Turing Way

		Data	
		Same	Different
Analysis	Same	Reproducible	Replicable
	Different	Robust	Generalisable

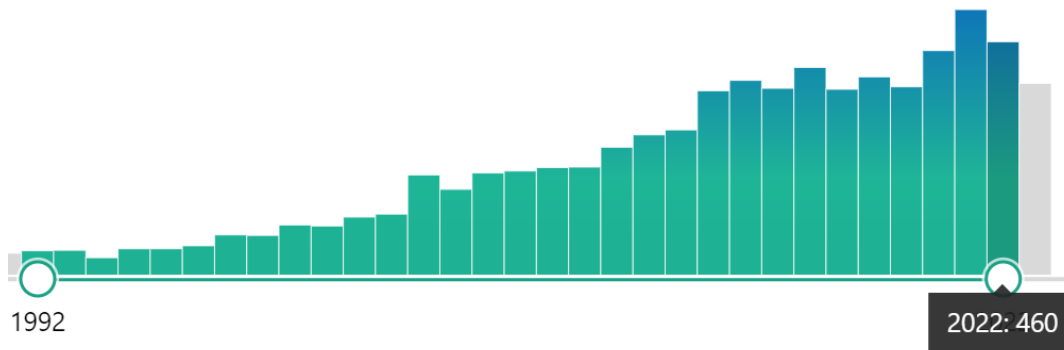
The Turing Way Community. (2022). The Turing Way: A handbook for reproducible, ethical and collaborative research. Zenodo. doi: 10.5281/zenodo.3233853 ([link to the schema](#))

The data deluge in EEG/MEG, as for science in general



“eeg results”

➔ 72 951 publications



“meg results”

➔ 5 934 publications

Why Most Published Research Findings Are False

John P. A. Ioannidis

74,946 Save	7,388 Citation
3,001,940 View	9,576 Share

Inadequate methodologies

A result is all the more likely to be false when:

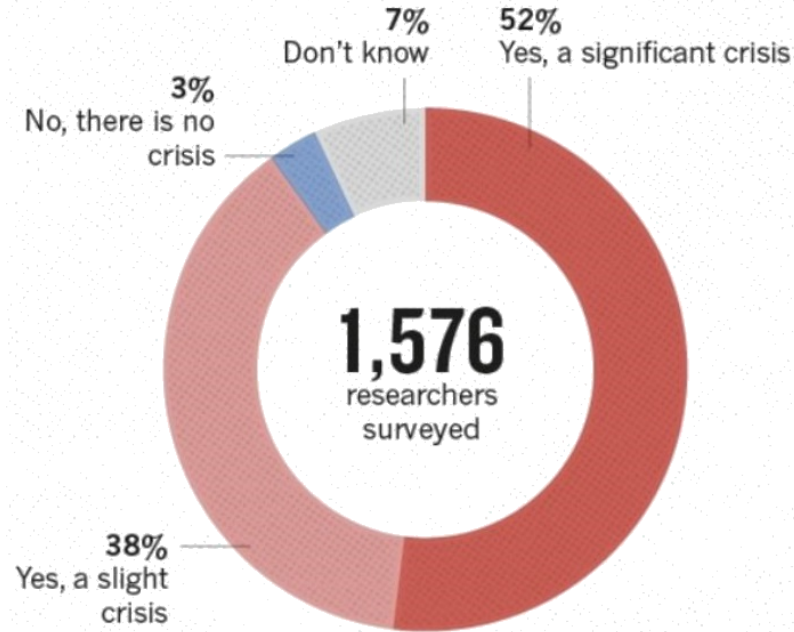
- **effect sizes** are small
- there is a **greater number and lesser preselection** of tested relationships
- there is **greater flexibility** in designs, definitions, outcomes, and analytical modes
- there is greater **financial and other interest** and prejudice

+ the propensity of **journals to publish only positive results**

+ the "**publish or perish**" culture for researchers

Ioannidis (2005) Why most published research findings are false. *PLoS Med* DOI: 10.1371/journal.pmed.0020124

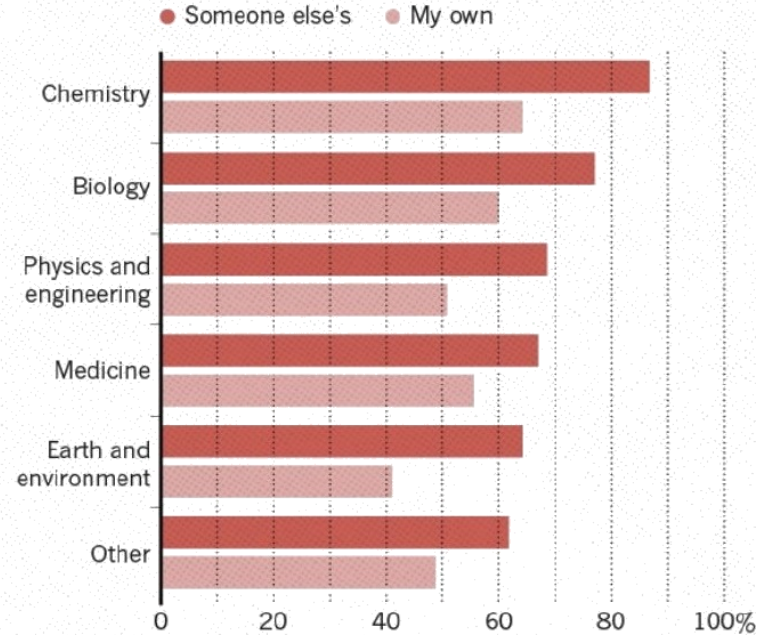
IS THERE A REPRODUCIBILITY CRISIS?



©nature

HAVE YOU FAILED TO REPRODUCE AN EXPERIMENT?

Most scientists have experienced failure to reproduce results.



Baker (2016) 1,500 scientists lift the lid on reproducibility. *Nature*. <https://doi.org/10.1038/533452a>

~~Science~~ Broken Science

- Paywall
- Non-shared data
- Closed tools & Software
- Non-reproducible
- Anonymous peer-review
- Publish or Perish



ReScience
Reproducible science is good. Replicated science is better.

~~Open science~~ Science

- Open access
- Open data
- Open source
- Open methodology
- Open peer-review
- Much more fun...

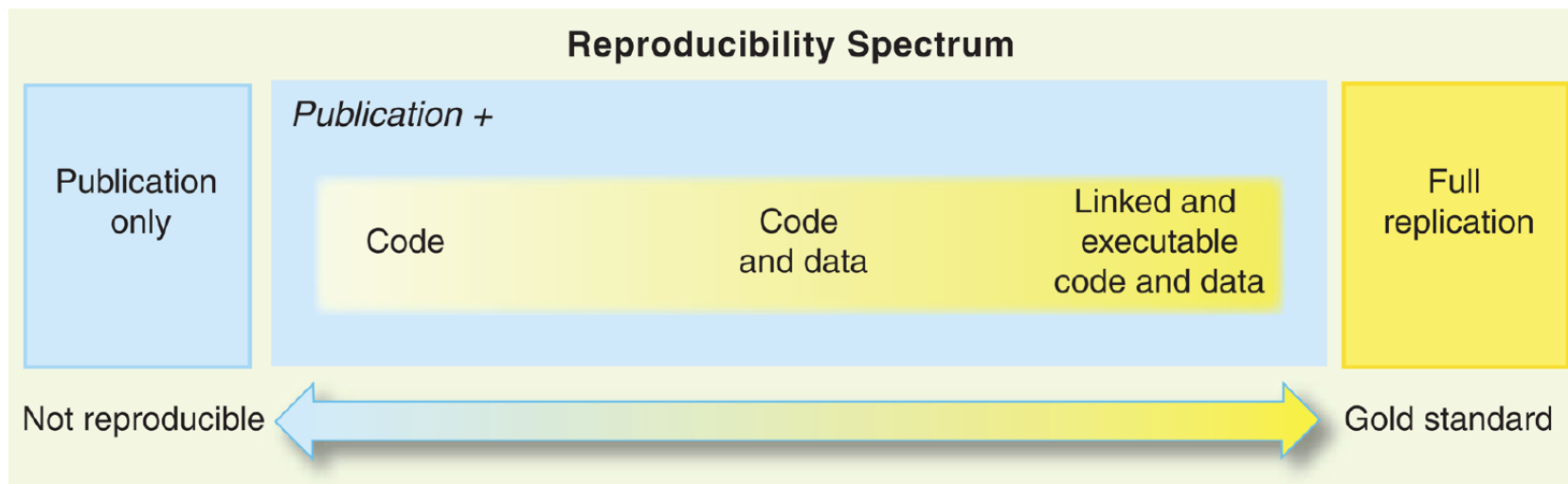


Roesch et al. (2019) ReScience X: Redoing experiments. osf.io/ede88 | slides: osf.io/uypbc6/

NO TRANSPARENCY NO CONSENSUS



https://pbs.twimg.com/media/Cjc_UC4XAAAKaJl.jpg:large



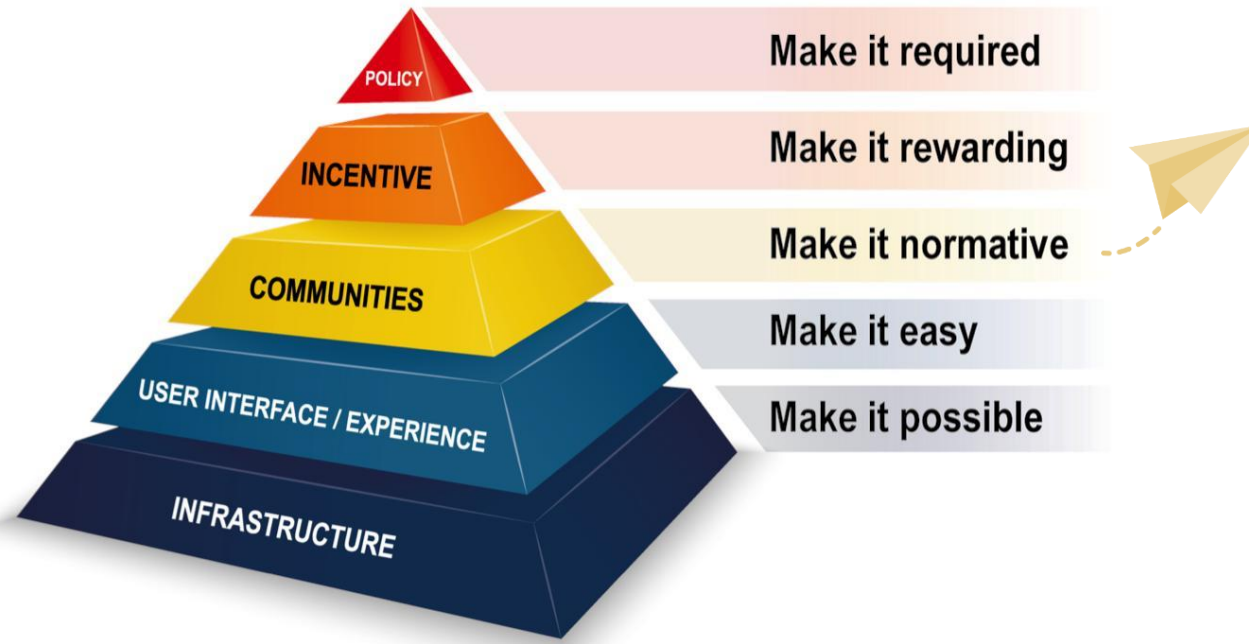
Peng (2011) Reproducible Research in Computational Science. *Science* <https://doi.org/10.1126/science.1213847>



Key message #1: reproducibility is not binary but rather a continuum

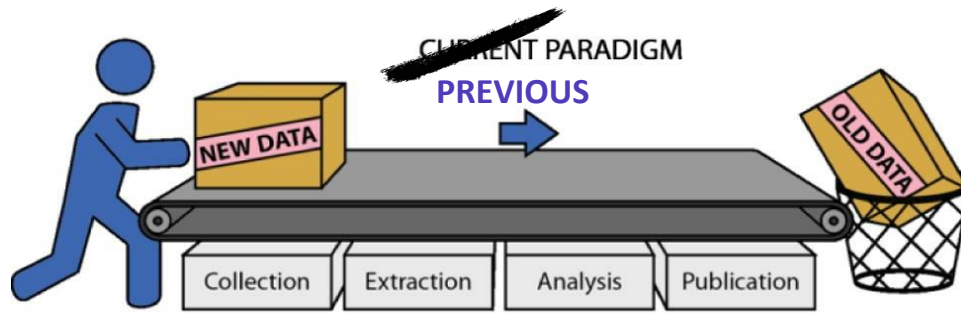
Image credit: icon made by Freepik on www.flaticon.com

Open science is a cultural change



Key message #2:
data sharing is
becoming the norm in
neuroImaging

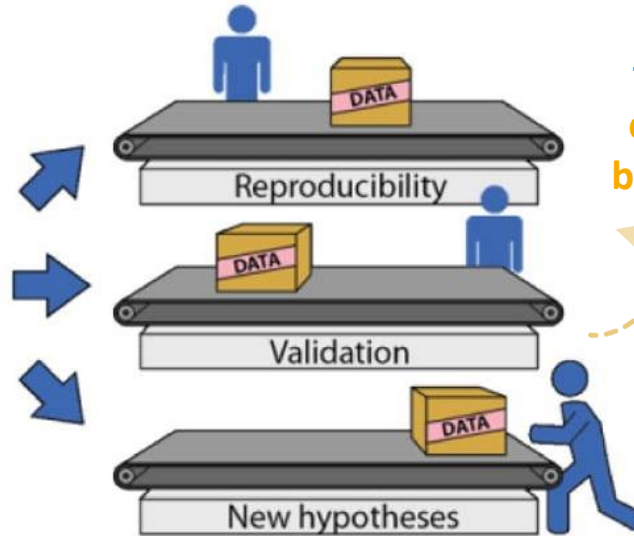
I might add another layer at the bottom of the pyramid:
"Raise awareness of the problem."
Burk, 2023. [Source](#)



Key message #3
for project leaders:
consider data
sharing from the
beginning



Key message #4
for project leaders:
consider data reuse
before collecting new
ones



Lambin, P. et al. (2013) Rapid Learning health care in oncology - an approach towards decision support systems enabling customised radiotherapy'. *Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology*. <http://dx.doi.org/10.1016/j.radonc.2013.07.007>

An open ecosystem of open tools

STUDY INCEPTION AND PLANNING



Study Preparation

Ensure quality of data and design

- Release Standard Operating Procedures
- Pilot your experiment



<https://compose.neurosynth.org/>
protocolexchange

 protocols.io



<https://dmp.opidor.fr/>



Pre-Registration

Have a thorough research plan:
study design, hypotheses and
analysis

- Follow best practices
- Use pre-registration / Registered Reports, report deviations



OSF
PREREGISTRATION



AS PREDICTED

ClinicalTrials.gov

Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.

<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>

Pre-registration of a project with peer-reviews: “registered reports”



<https://www.cos.io/initiatives/registered-reports>

Registration Forms and Templates: <https://osf.io/zab38/wiki/home/>

Nosek et al. (2018) The preregistration revolution. *Proc. Natl Acad. Sci. USA* <https://doi.org/10.1073/pnas.1708274114>

Nosek & Lakens (2014) Registered reports: a method to increase the credibility of published results. *Soc. Psychol.*

<https://doi.org/10.1027/1864-9335/a000192>

Pre-registration of a project with peer-reviews: “registered reports”

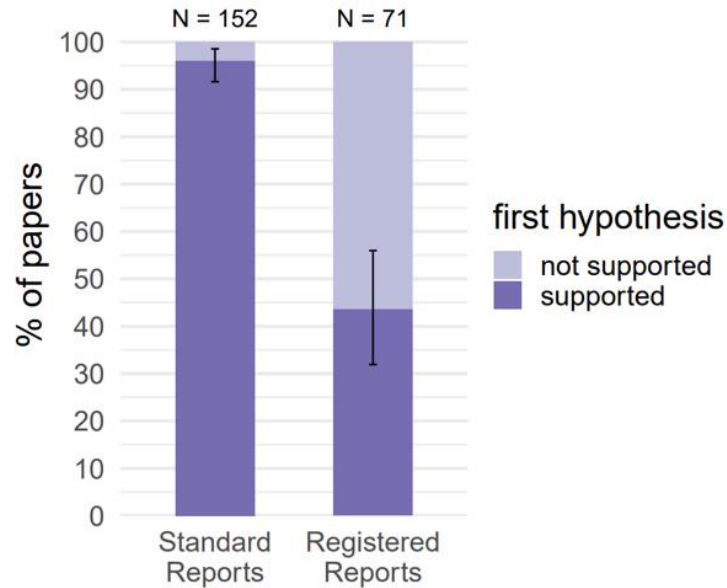


Figure 2. Positive result rates for standard reports and Registered Reports. Error bars indicate 95% confidence intervals around the observed positive result rate.

Scheel et al. (2021) An excess of positive results: Comparing the standard Psychology literature with Registered Reports. *Advances in Methods and Practices in Psychological Science*. <https://doi.org/10.1177/25152459211007467>

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OSF

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AS PREDICTED

ClinicalTrials.gov



Ethics and Sharing plan

Meet ethical and regulatory requirements

- Informed consent
- Internationally oriented data governance



Open Brain
Consent



Monitoring Quality

Ensure quality of acquired data

- Establish quality control checkpoints
- Quality assurance
- Include positive control analyses



MRIQC

XNAT



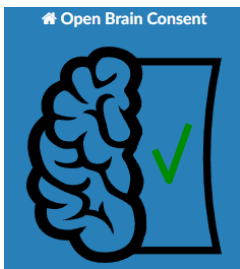
Qoala-T



VisualQC

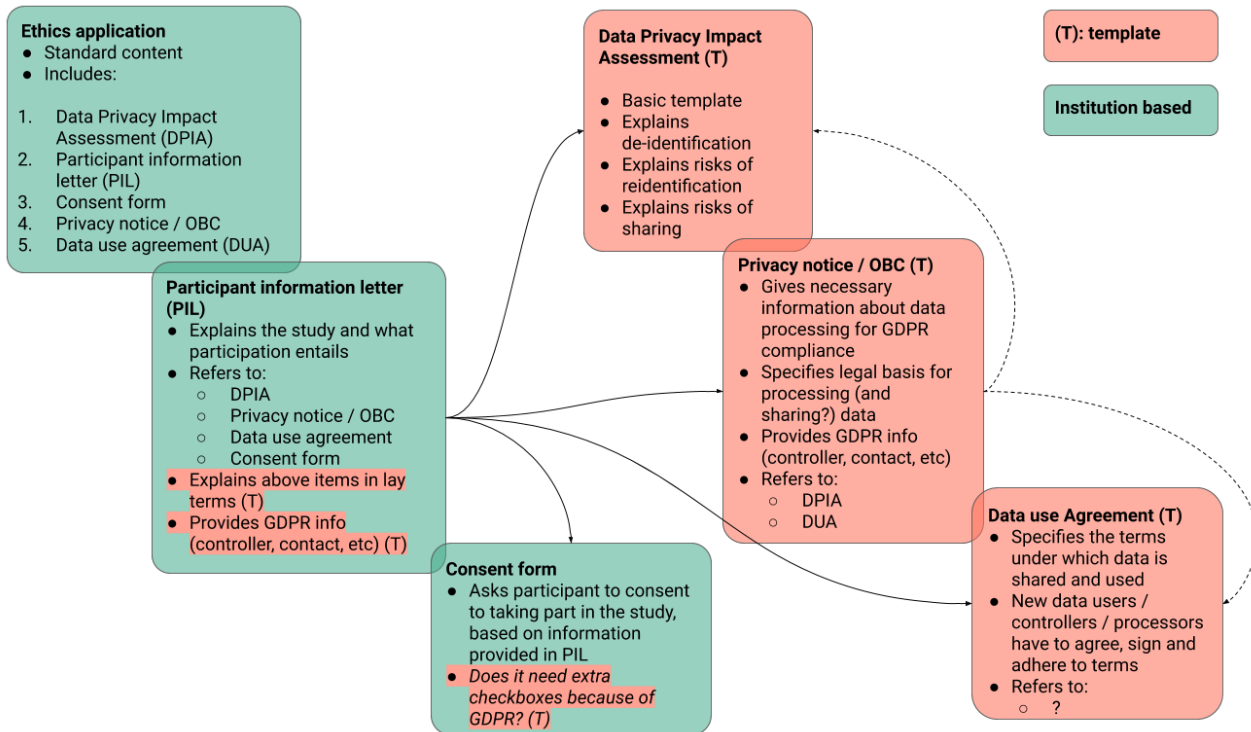
Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.

<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>



Make open data sharing a no-brainer for ethics committees

Sample consent forms & data user agreement in many languages (English, French, Italian, Spanish, etc.)



<https://open-brain-consent.readthedocs.io/en/stable/gdpr/index.html#gdpr-documents>

Bannier et al. (2021) The Open Brain Consent: Informing research participants and obtaining consent to share brain imaging data. *Hum Brain Mapp.* <https://doi.org/10.1002/hbm.25351>

An open ecosystem of open tools

DATA ACQUISITION



Brain Data

Transparent and reproducible data acquisition

- Use open hardware
- Use open software
- Report full acquisition details



Stimulus

Reproducible stimulus presentations

- Report detailed stimuli, timings, responses, etc.
- Use open frameworks and share stimulus materials



RESEARCH DATA MANAGEMENT



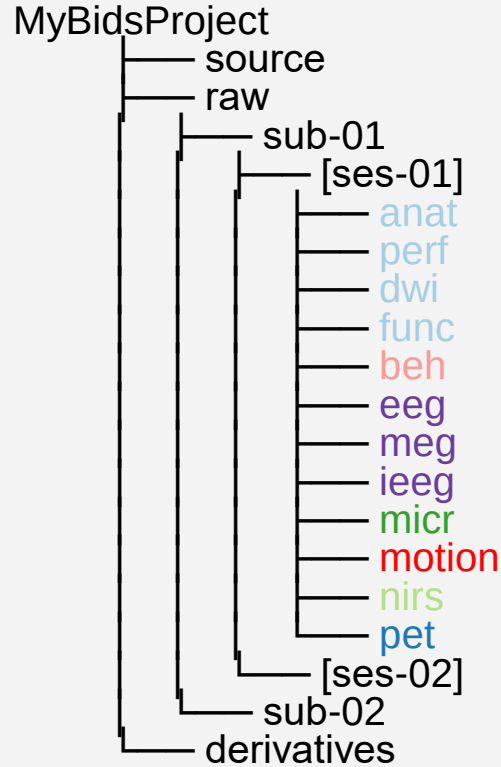
Data organization and standards

Ensure data are interoperable and reusable

- Organize your neuroimaging data following the Brain Imaging Data Structure (BIDS)
- Utilize available tools, converters and apps that work with BIDS



Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.
<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>



	modality						
datatype	MRI	PET	meeg	behavioral	microscopy	NIRS	motion
	anat	pet	eeg	beh	micr	nirs	motion
	func		meg				
	dwi		ieeg				
	perf						

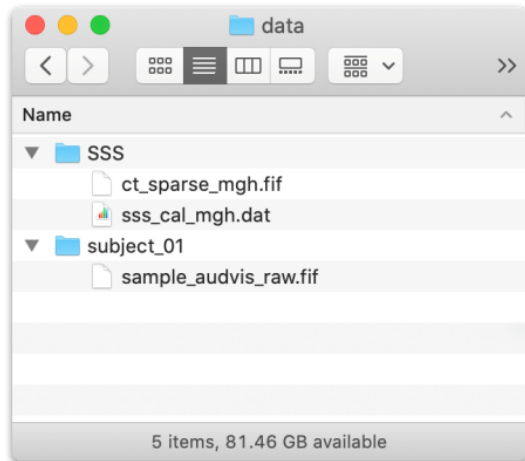
To be extended to:

- Animal electrophysiology
- Eyetracking
- Magnetic resonance spectroscopy
- ...

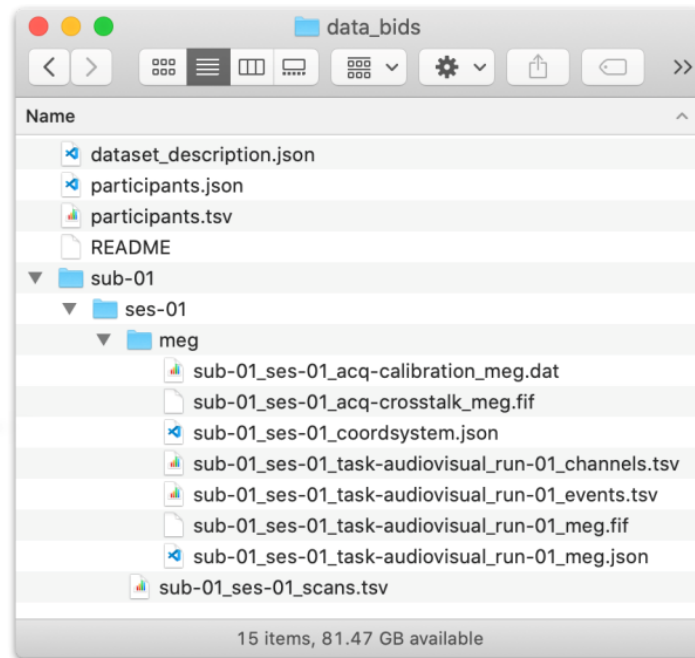
```
sub-01
├── ses-01
│   ├── anat
│   │   └── sub-01_ses-01_T1w.nii.gz
│   └── eeg
│       ├── sub-01_ses-01_task-olfloc_run-01_eeg.edf
│       ├── sub-01_ses-01_task-olfloc_run-01_events.tsv
│       └── sub-01_ses-01_task-olfloc_run-01_channels.tsv
```

[Slide from pres. Rémi Gau @CRNL 2023](#)

Pernet et al. (2019) EEG-BIDS, an extension to the brain imaging data structure for electroencephalography. *Sci Data* <https://doi.org/10.1038/s41597-019-0104-8>



Arbitrarily organized data



BIDS-compliant dataset

<https://github.com/mne-tools/mne-bids>

Niso et al. (2018) MEG-BIDS, the brain imaging data structure extended to magnetoencephalography. *Sci Data* <https://doi.org/10.1038/sdata.2018.110>

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Metadata and data annotation

Ensure data are understandable, interoperable and reusable

- Annotate data using established structures
- Track provenance with Neuroimaging Data Model (NIDM)



Data management and tracking

Track and version control data for update, retrieval, and reuse

- Use open data hosting services
- Use tools for decentralized data management



Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.

<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>

An open ecosystem of open tools

DATA PROCESSING AND ANALYSIS



Software

Choose from the many open tools available

- Implement best practices when writing code, and share openly
- Test for analytical robustness



Standardizing workflows

Enhance reproducibility

- Use standardized workflows for automation, reproducibility and transparency
- Use containers to ensure computational reproducibility



Statistical modelling

Focus on reproducibility and transparency

- Use analysis pipelines with automatic (machine readable) documentation
- Use standardized structures



Multiverse analysis

Explore effects of variations in analysis pipeline on study results

- Vary critical analysis parameters
- Re-run analysis with different tools and test for robustness



Key message #5:

Open data and analysis software are essential for reproducibility in data analysis

Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.

<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>



[The Open MEG Archive \(OMEGA\)](https://mcgill.ca/bic/resources/omega)



The multidisciplinary
archive for French
research <https://hal.science/>

DISSEMINATION



Data sharing

FAIR (Findable, Accessible, Interoperable, Reusable)

- Standardize data with rich metadata, and share it under persistent identifiers on public repositories and a license
- Publish Data Descriptors



Code sharing

FAIR for reproducible analysis

- Document code and share it on public repositories + license
- Use version control
- Use containers



Derived data sharing

FAIR derived data and results

- Share results of analyses in an interoperable and understandable way, so they are reusable and reproducible



Paper publication

Publish with openness and reproducibility in mind

- Follow best practices
- Publish on preprint servers and/or open access journals



Software Heritage

<https://www.softwareheritage.org/>



cascad
the first certification
agency for scientific
code & data
<https://www.cascad.tech/>

Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.
<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>

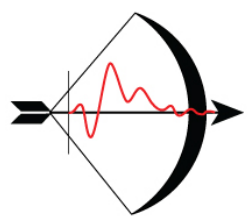
Artemis

English (US) ▼

- ☐ study_id
- ☐ Design and sample
- ☐ Hardware
- ☐ Acquisition
- ☐ Preprocessing
- ☐ Measurement
- ☐ Channel choice
- ☐ Visualization
- ☐ Other

Home

ARTEMIS readme



ARTEM-IS

Agreed Reporting Template for EEG Methodology - International Standard: template for event-related potentials (ERP)

The goal of the ARTEM-IS is to use insights derived from systematic reviews to create human-friendly, machine-readable templates for documenting the methodological details of an EEG study or pipeline. The template for reporting ERP methodology before you is a pilot project of ARTEM-IS, based on which other subfields of EEG may follow.

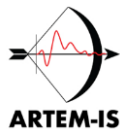
https://remi-gau.github.io/artemis_checklist/#/

Pernet et al. (2018) Best Practices in Data Analysis and Sharing in Neuroimaging using MEEG. <https://doi.org/10.31219/osf.io/a8dhx>

Pernet et al. (2020) Issues and recommendations from the OHBM COBIDAS MEEG committee for reproducible EEG and MEG research. *Nat Neurosci*



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The multidisciplinary archive for French research

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Beyond publication

Disseminate scientific results to the broader scientific community and to the society in general

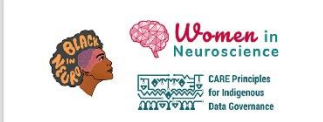
- Conferences, workshops, mass media, social networks



Inclusive, diverse community research

Open resources and welcoming spaces, diversity of ideas and approaches

- Equity, diversity and inclusivity
- Impact on careers, work-life balance, and mental health

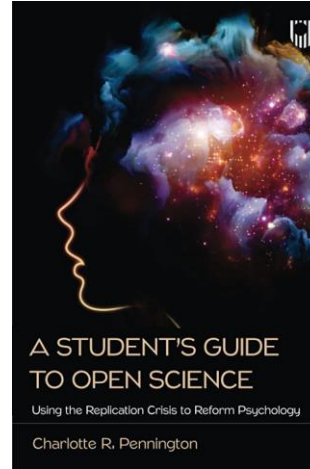


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<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>

Some readings

The thematic booklets of the Passport for Open Science collection are now **available in english!**



Workshops



<http://open-neuro.org>

National Reproducibility Network

Grenoble, France
26-28th March 2024

<https://www.recherche-reproductible.fr/>



Where ever we are on the Open Science journey: there are tools to make it easier and more reproducible.

You're not alone!
You're surrounded by people
happy to help in your
communities



Humans make mistakes: self-correct the
bugs and check the impact of them.

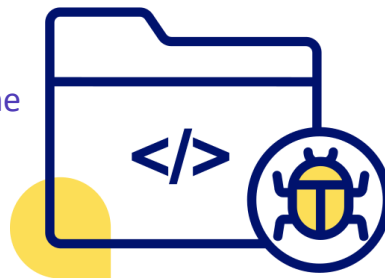


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This work has been only possible with the valuable help of:

Olivier Bertrand, Director of the CRNL



The Open Science group at the CRNL: Pierre-Emmanuel Aguera, Olivier Bertrand, Laurent Bezin, Anne Cheylus, Justine Épinat-Duclos, Alexandra Fargeot, Guillaume Sescousse*



CRNL think tanks on scientific integrity led by Fabien Chauveau, Nicolas Fourcaud-Trocmé, Nicolas Grimault, Nicola Kuczewski*; **on Methodology** led by Alexandra Corneyllie & Françoise Lecaigard* and **on NeuroImaging** with Justine Épinat-Duclos & Isabelle Failletot*

CRNL working groups on Open Access, Data Management Plans, Electronic Lab Notebooks



Inspiring colleagues in networks & communities



Former and current colleagues who support and challenge open science to make a better science.

* Alphabetical order