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## Open science: a dynamic ecosystem

Gaëlle Leroux

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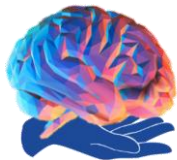
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# Open Science: a dynamic ecosystem



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](#)



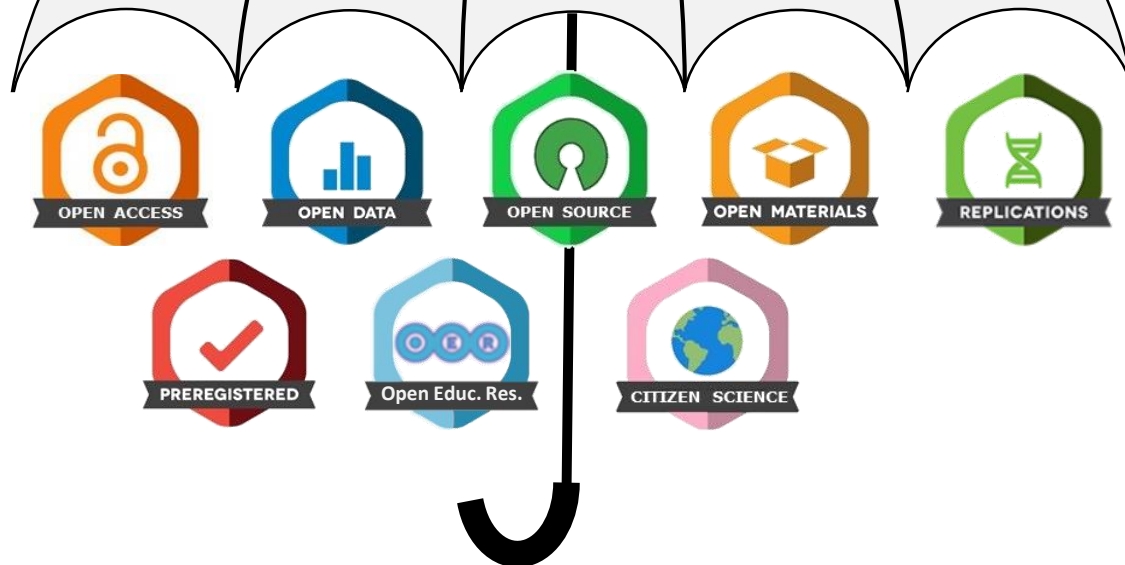
“Open science is a movement that aims to **involve new stakeholders, such as everyday citizens and non-research organisations**, in the research process, and to **make the products of research** — everything from scientific publications and data to software programs — **more accessible and reusable for 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](http://www.flaticon.com) & Bonazzi/Salzmanart (2022) *Science*. doi:10.1126/science.adf4323

# Open Science



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](#)*



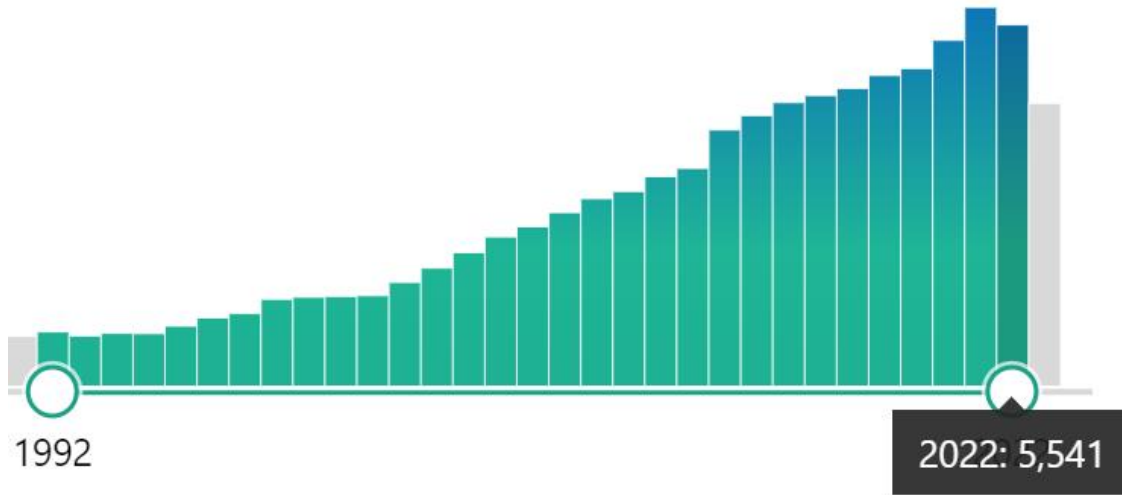
The Turing Way

		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](#))

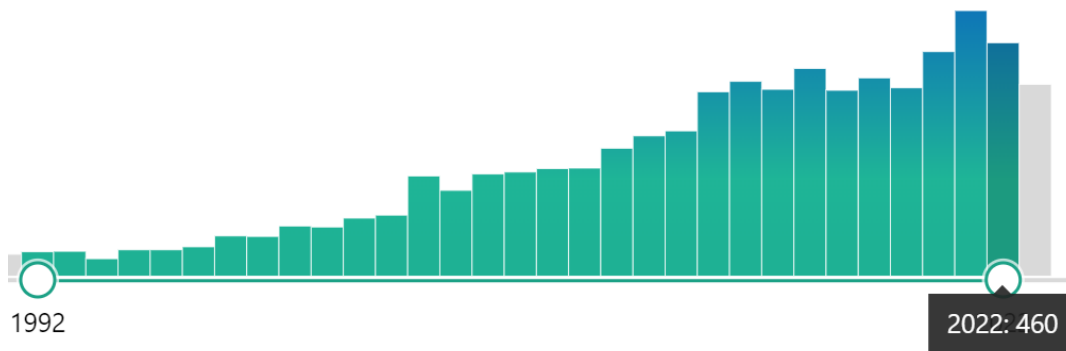


# The data deluge in EEG/MEG, as for science in general



“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

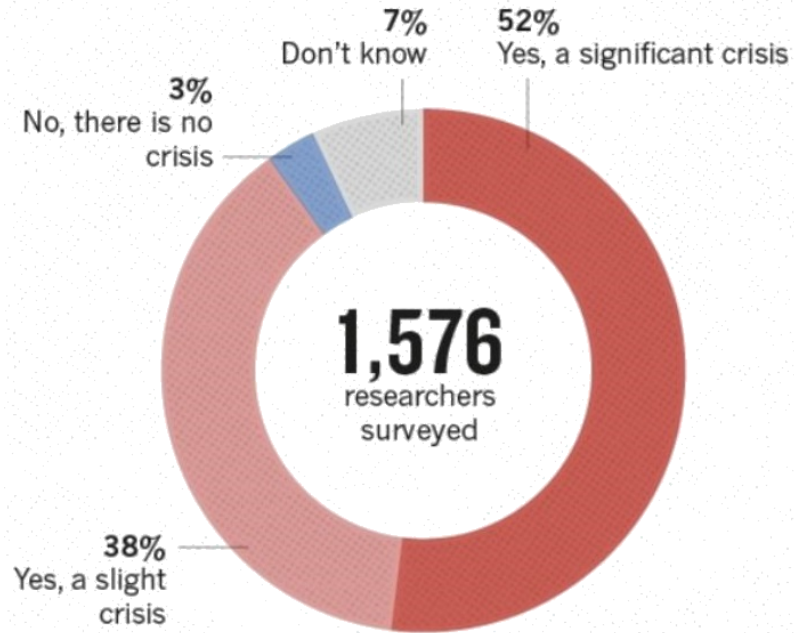
A result is all the more likely to be false when:

- **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

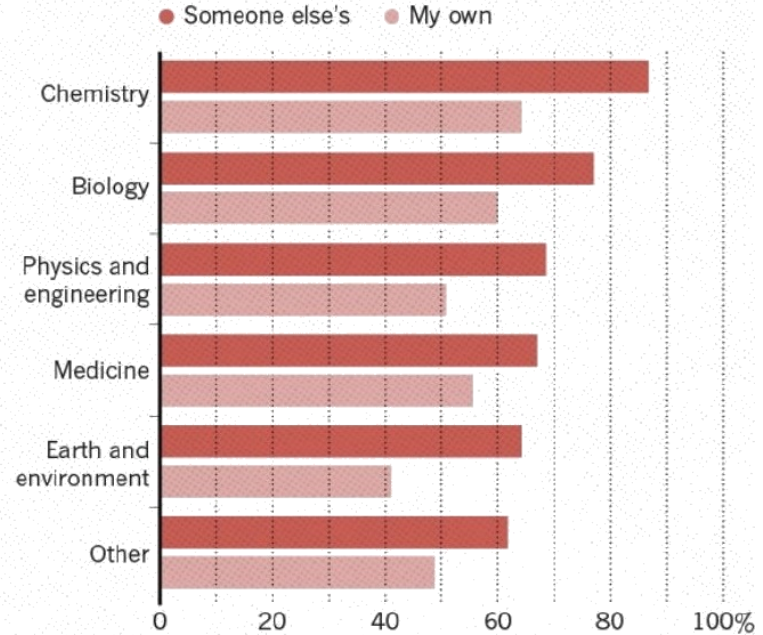
## IS THERE A REPRODUCIBILITY CRISIS?



©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.

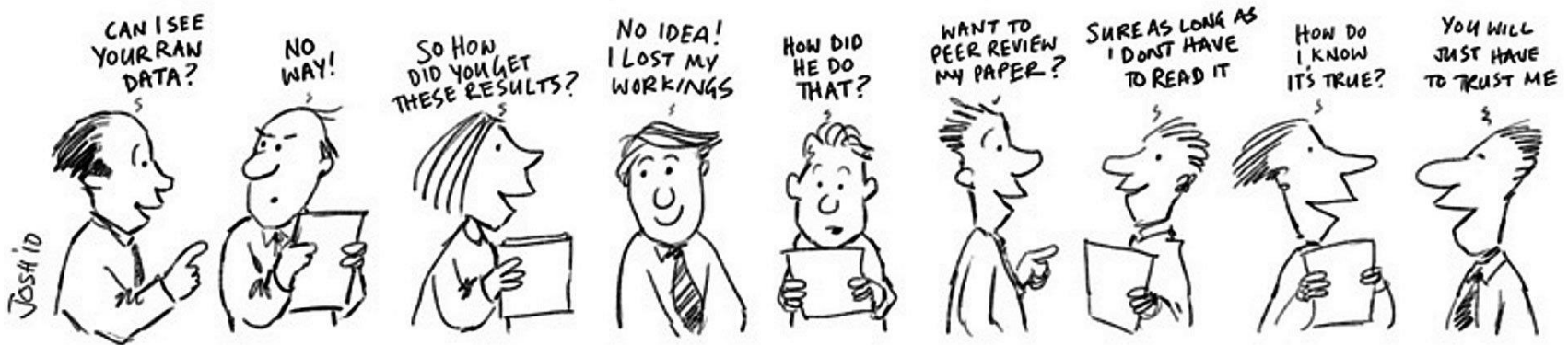
## ~~Open science~~ Science

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

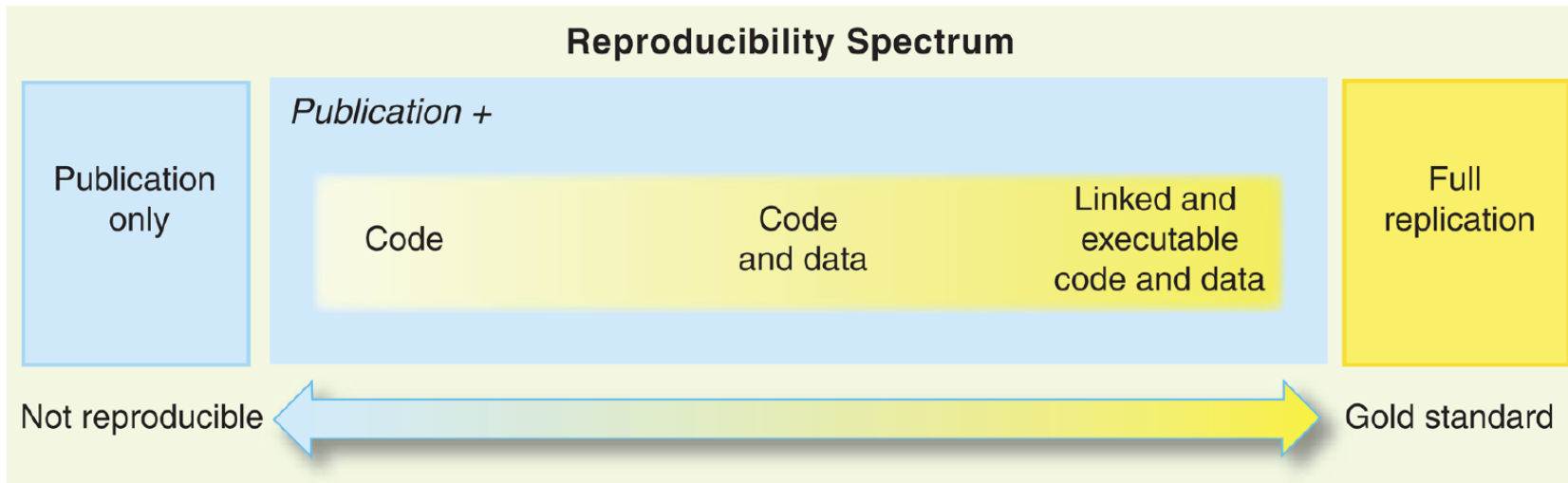


Roesch et al. (2019) ReScience X: Redoing experiments. [osf.io/ede88](https://osf.io/ede88) | slides: [osf.io/uyc6/](https://osf.io/uyc6/)

# NO TRANSPARENCY NO CONSENSUS



[https://pbs.twimg.com/media/Cjc\\_UC4XAAAKaJl.jpg:large](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**

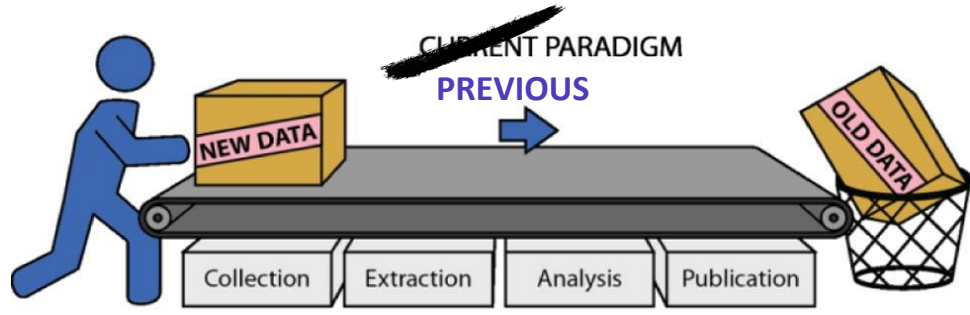
Image credit: icon made by Freepik on [www.flaticon.com](http://www.flaticon.com)

# Open science is a cultural change



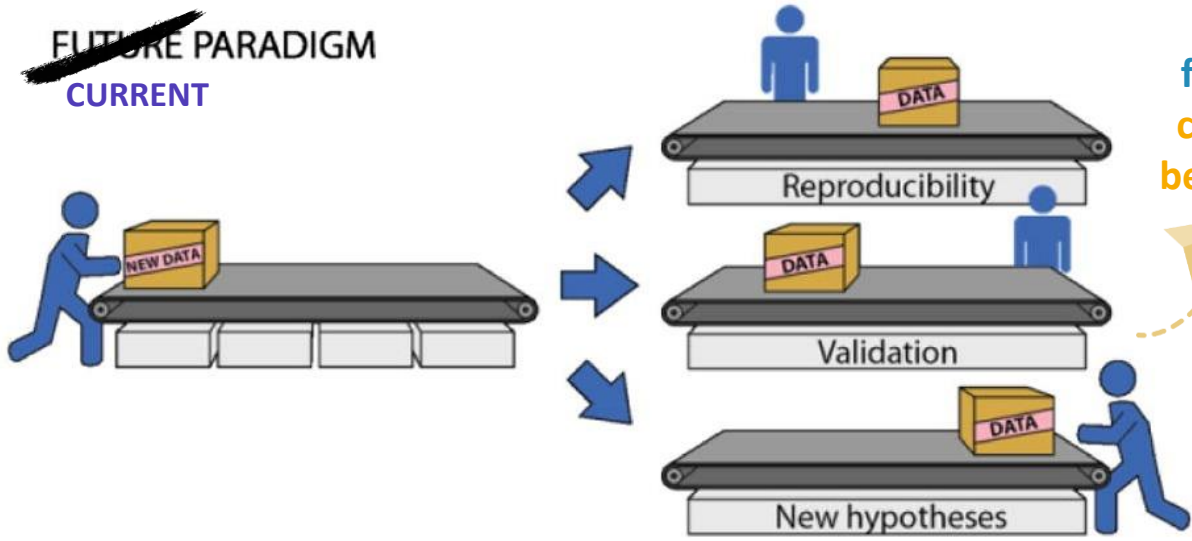
**Key message #2:**  
data sharing is  
becoming the norm in  
neuroImaging

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

~~FUTURE PARADIGM~~  
**CURRENT**



**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>

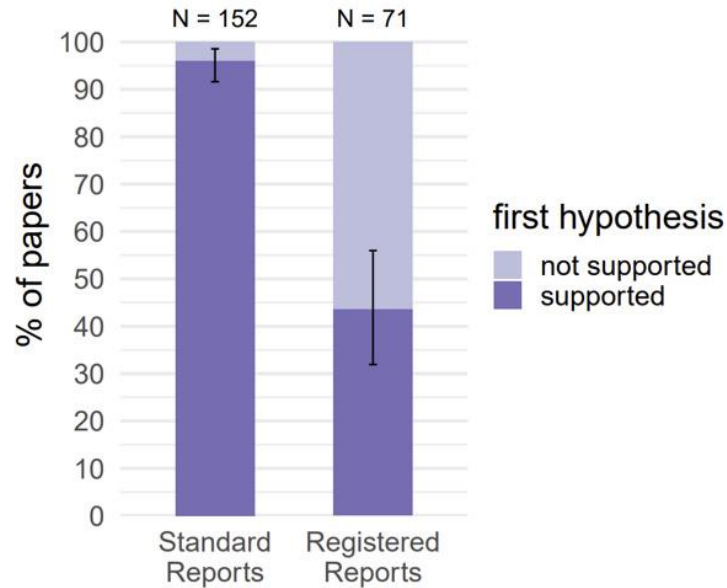
Registration Forms and Templates: <https://osf.io/zab38/wiki/home/>

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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*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



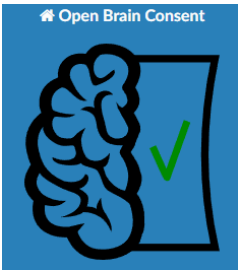
Goala-T



VisualQC

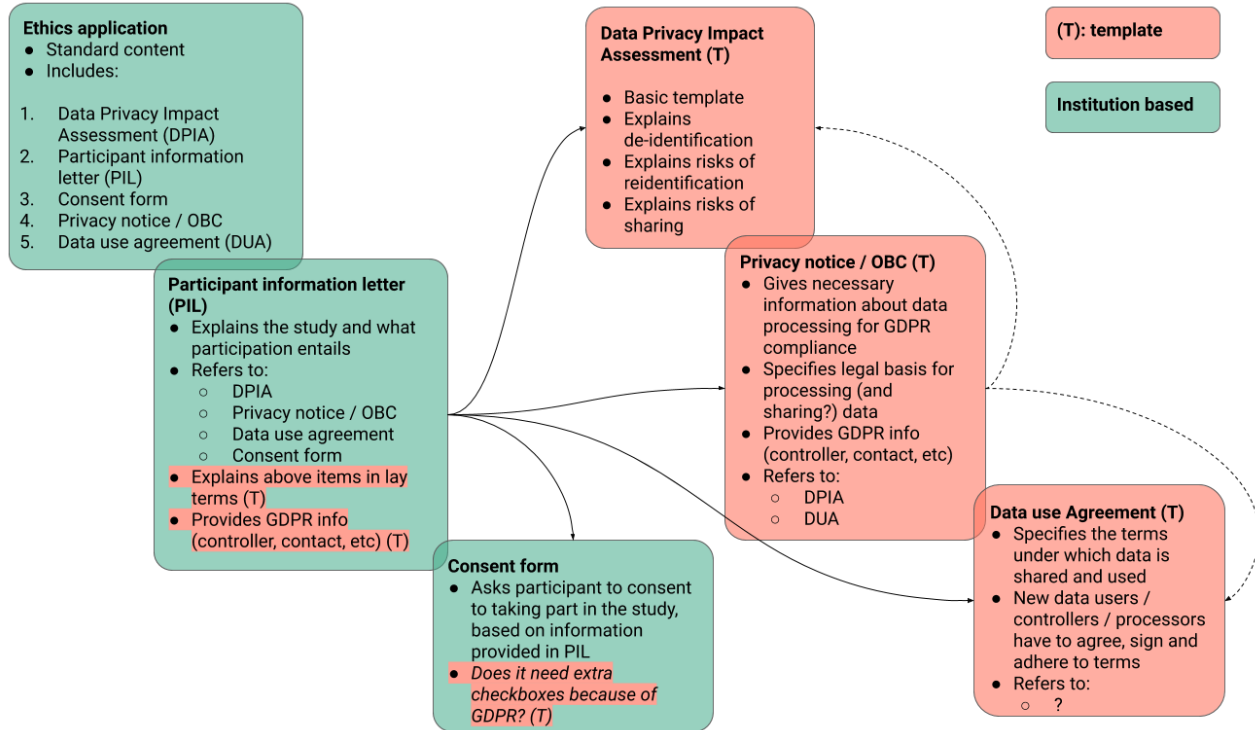
Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.

<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>

Banner 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



Labguru



eLabFTW

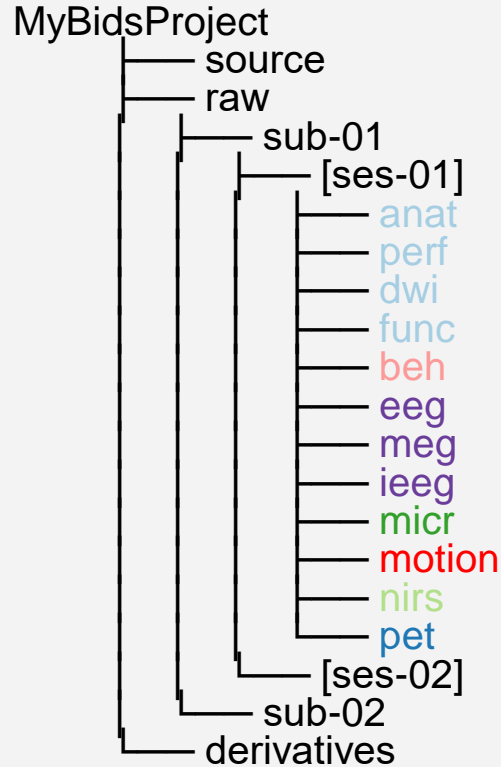


**BIDS**  
BRAIN IMAGING DATA STRUCTURE

<https://bids.neuroimaging.io/>

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

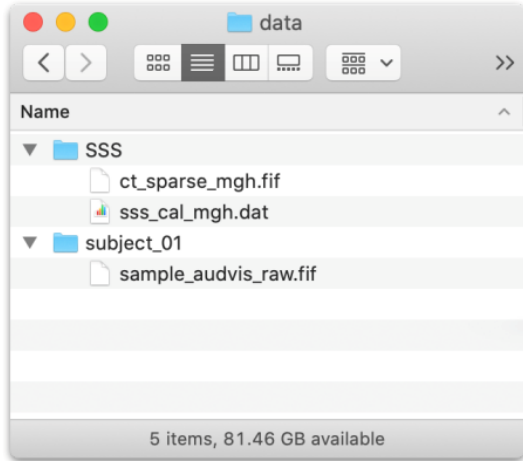
To be extended to:

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

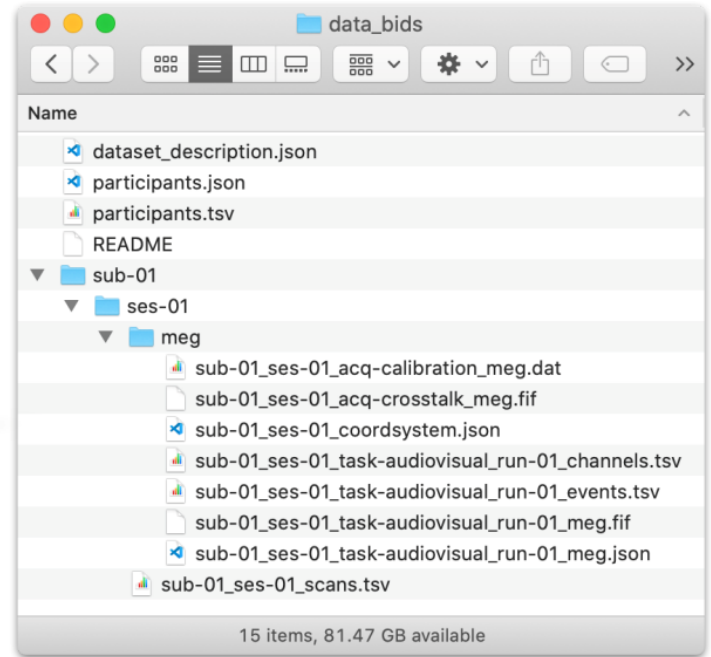


[Slide from pres. Rémi Gau @CRNL 2023](#)

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)

## 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

**cascad**

### 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/>

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

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/#/](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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**Paper publication**

**Publish with openness and reproducibility in mind**

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**Beyond publication**

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

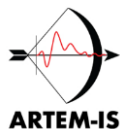
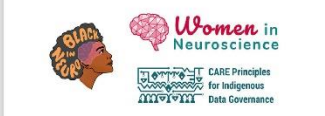
- Conferences, workshops, mass media, social networks



**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

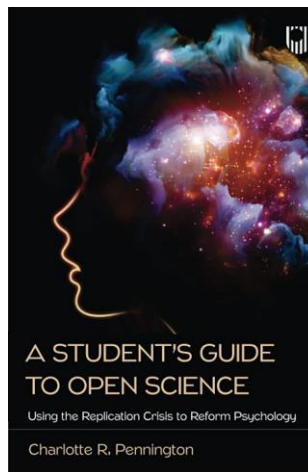


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Niso et al. (2022) Open and reproducible neuroimaging: From study inception to publication. *NeuroImage*.  
<https://doi.org/10.1016/j.neuroimage.2022.119623> - <https://oreoni.github.io/index.html>

## Some readings

The thematic booklets of the Passport for Open Science collection are now [available in english!](#)



Duration: 4 weeks    Effort: 8 hours    Pace: Self paced

Languages: English and french

## Workshops



<http://open-neuro.org>

National Reproducibility Network

Grenoble, France  
26-28<sup>th</sup> 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.

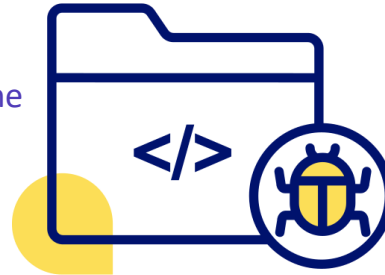


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This work has been only possible with the valuable help of:

**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