Universität Rostock Traditio et Innovatio

# Towards Open Science in Acoustics

## Foundations and best practices

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# The Scientific Method

- formulation, testing, and modification of hypotheses
- systematic observation, measurement, and experiment
- reproducibility

**Branches** [Donoho 2009, Stodden 2014a]

1. deductive $\longrightarrow$ mathematics, formal logic
2. empirical $\longrightarrow$ statistical analysis of controlled experiments
3. computational
   - large-scale simulations
   - data-driven computational science

   } potentially new branch(es)

# Who Should Benefit from my Research?

- myself

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- ☐ myself
- ☐ my future self

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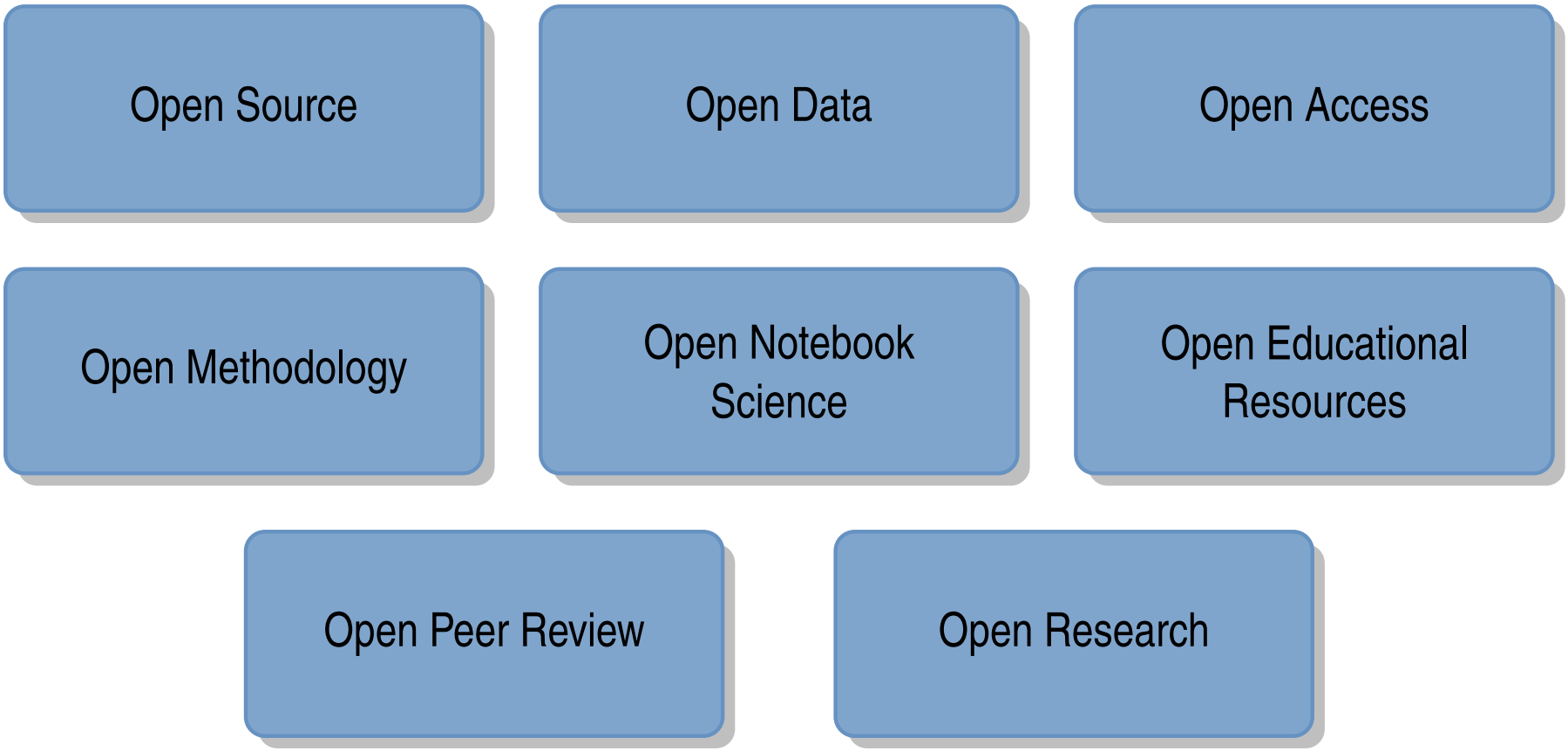
- ☐ all people in the world
- ☐ science itself

# The Elements of Open Science

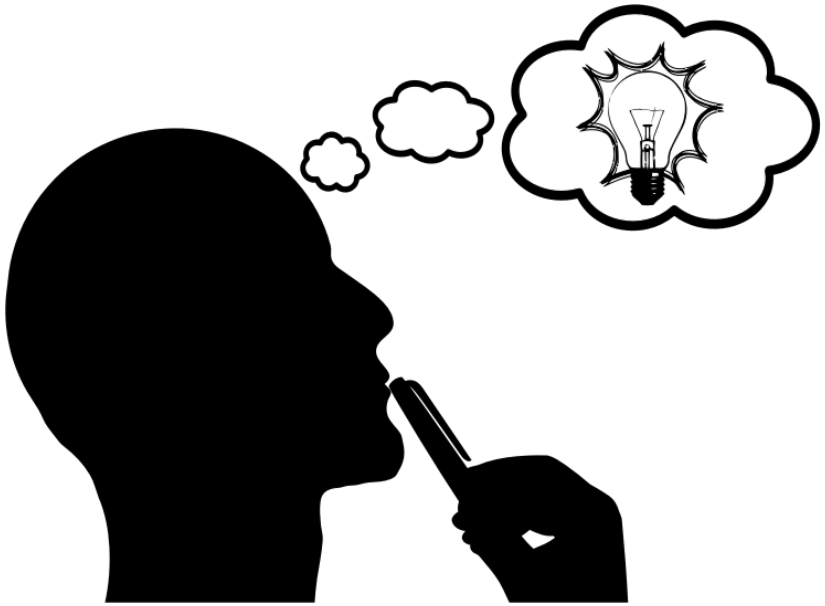



compiled from `https://en.wikipedia.org/wiki/Open_science` and `http://openscienceasap.org/open-science`

# Example – Perceptual Study

## Procedure

1. Idea
2. Design of experiment
3. Computation
4. Experiment
5. Analysis
6. Manuscript
7. Peer review
8. Publication
9. Aftermath



from https://openclipart.org/

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- hypothesis
- procedure
- stimuli
- test subjects
- ...

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Open Methodology

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- mathematical derivations
- numerical simulations
- generation of stimuli
- control logic, GUI

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Open Notebook Science

Open Data

Open Source

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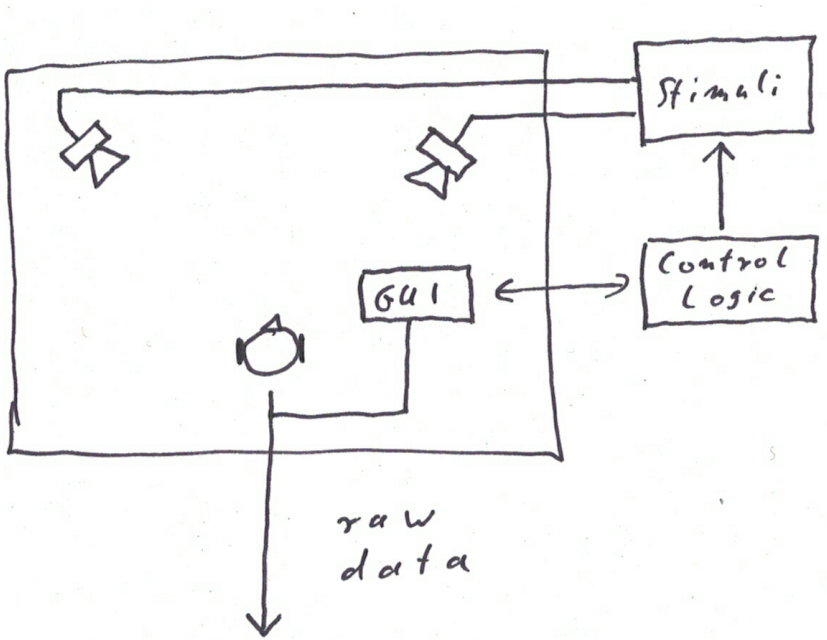

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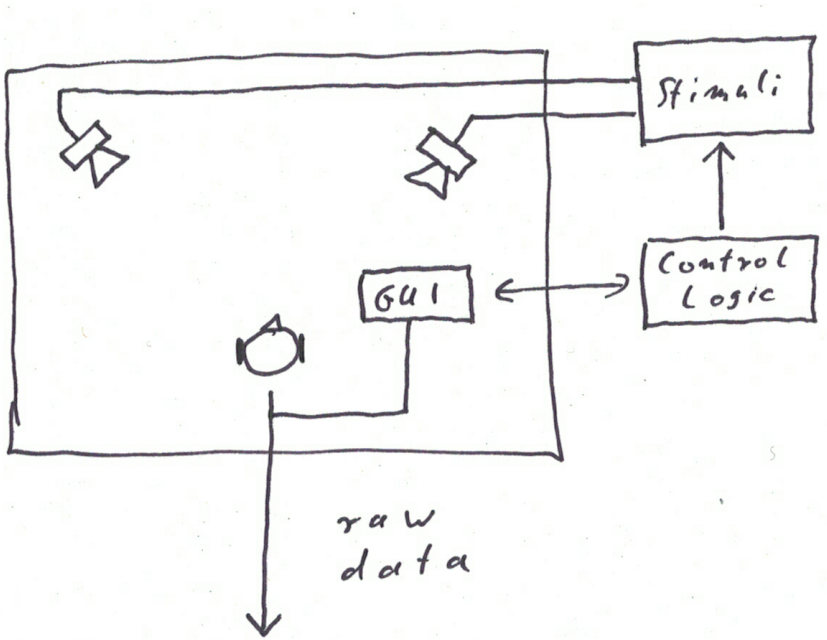


Open Data

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- anonymization of data
- outlier removal
- statistical analysis

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Open Methodology

Open Source

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- text
- references
- visualization of results (plots)

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Open Access

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- ratings, comments
- revised manuscript

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- ratings, comments
- revised manuscript

Open Peer Review

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- manuscript
- supplementary materials
- presentation

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- reproduction by third parties
- post-publication review
- errata, code and data revision
- ideas for next study...

# Incentives and Barriers

## Selected results from a survey of the machine learning community

**Barriers** [Stodden 2014], N=134

- time to document and clean up (54/77 %) (Data/Code)
- dealing with questions from users (34/52 %)
- not receiving attribution (44/42 %)
- possibility of patents (–/40 %)
- legal barriers (e.g. copyright) (34/41 %)

**Incentives**

- encourage scientific advancement (81/91 %)
- encourage sharing in others (90/79 %)
- be a good community member (86/79 %)
- set a standard in the field (82/76 %)
- improve the calibre of research (85/74 %)

# Management of Research Data

- systematic management of research data is a prerequisite for open and reproducible science
- becoming mandatory (DFG, Horizon 2020, NSF, ...)

**Principles** [DFG 2013, HRK 2014, Stodden 2014b, H2020 2016]

- develop a comprehensive data management plan
- use workflow tracking in the research process
- make data findable, accessible, interoperable and reusable (FAIR)
- apply open licensing models
- offer training and qualification

# Copyright and Licenses

- unclear situation when publishing data without explicit license
- license should be as open as possible to promote re-use
- legal implications are complex and hard to oversee

**Available licensing frameworks**

- Software: GNU Public License, BSD, MIT, ...
- Content: Creative Commons, ...

**Recommendations**

- Reproducible Research Standard (RRS) [Stodden, 2009]
- ...

# Services for Open Science (Selection)

**Generic repositories**

- GitHub
- Bitbucket

**Repositories for research data**

- Zenodo
- runmycode
- datahub

**Virtual Research Environments**

- Open Science Framework (OSF)
- gCUBE
- hubzero

**Journals**

- Open Science Journal
- Journal of Open Research Software

# Personal Experience

- public release of the SoundScape Renderer (SSR) in 2010
- various toolboxes, datasets, open access papers, open educational resources
- internal data management: Redmine, svn, git
- public releases: github, zenodo, wordpress

**Challenges**

- initial effort (e.g. training)
- missing versioning tool/platform for (large) data bases

**Benefits**

- documentation/clean up/discussions for public release
- bug reports, positive community feedback
- potentially more citations [Brody 2006]

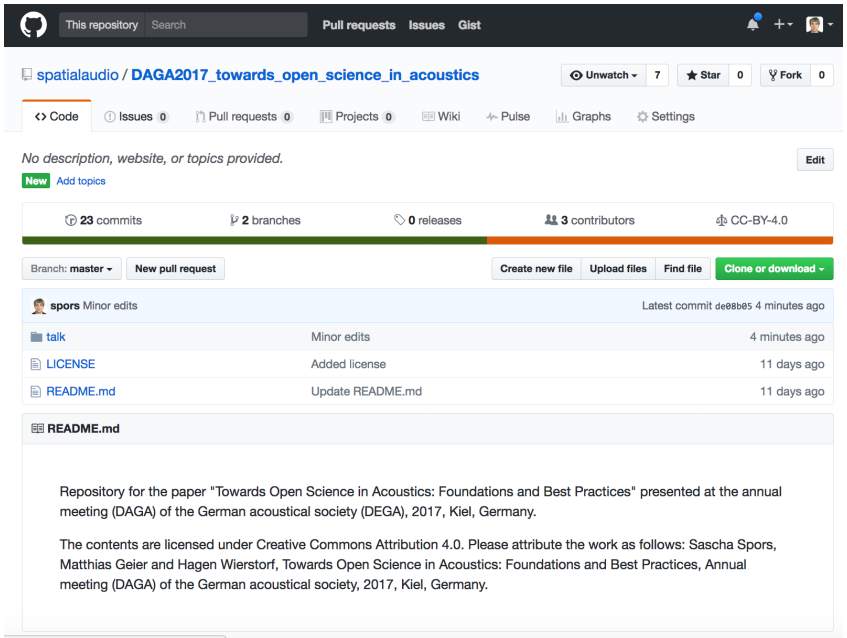
# Conclusions

- reproducibility of results is essential for the scientific method
- Open Science by itself does not ensure the ease of reproducibility
- evaluation measures contradict scientific innovation
- training and qualification required

`github.com/spatialaudio`

`github.com/twoears`

`spatialaudio.net`



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