Reproducible Research

...and how to implement it locally

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February 7, 2024

My Background

- Work on **computational magnetic resonance imaging**

- **Focus on open source software**: BART[1]

- Institute[2] is **strong in reproducible science**

    - Biannually reproducibility event days[3]

    - Publication of paper figure scripts[4,5,6,7] (CI framework for paper reproducibility)

    - Tutorials, Webinars, Workshops,...

    ⋮

[1]Berkeley Advanced Reconstruction Toolbox, M. Uecker et al., 2013.   [2]Institute of Biomedical Imaging, Prof. Dr. Martin Uecker   [3]Scholand, Zenodo, 2024
[4]Github:mrirecon/moba-irme   [5]Github:mrirecon/raga   [6]Github:mrirecon/bloch-moba-misc   [7]Github:mrirecon/bloch-moba
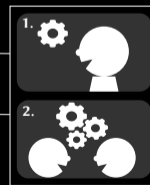
Outline

- **Local Influence of Reproducibility**

- **Learn About Reproducibility**

- **The Reproducibility Day**:
  Motivation, Concept and Experiences

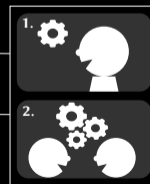| **The Reproducibility Day**		
Introduction		
Morning Block	**1.**	**Preproduce** Partners Work
Lunch		
Afternoon Block	**2.**	**Feedback** in Groups
Closing		
Social Gathering		

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Partners Work

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Global/Community Perspective

- **Democratize access** to research[1]

- **Enhance** accountability of **research integrity**[1]

- **Facilitate** the **self-corrective process** of science[1]

- May **increase productivity**[2]

⋮

[1]Center for Open Science, @cos.io/about, 09.01.2024   [2]OECD Science, Technology and Industry Policy Papers, No. 25.

Global/Community Perspective

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→ **Local Perspective**

Local Influences of Reproducibility

Institutional

Personal

Local Influences of Reproducibility: **Institutional**

- **Impact Reduction** of personnel fluctuations
- Knowledge Distribution
- Documentation
- Networking & Collaboration
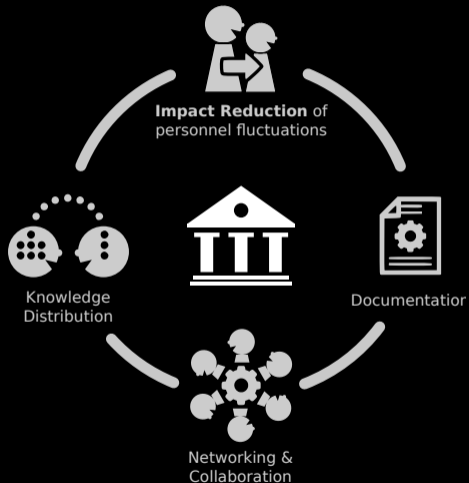
- **Improves documentation** and **collaborations**

- Simplifies **knowledge distribution**

- **Reduces impact** of **personnel fluctuations**

Local Influences of Reproducibility: **Personal**

General:

- **Protects** from accusations of research misconduct[1]

- **Increases** paper **citation rates**[2,3]

- Strong indicator of **rigor**, **trustworthiness**, and **transparency**[1]

Tools

Explain/Share

Protection

Feedback

Increase Citations
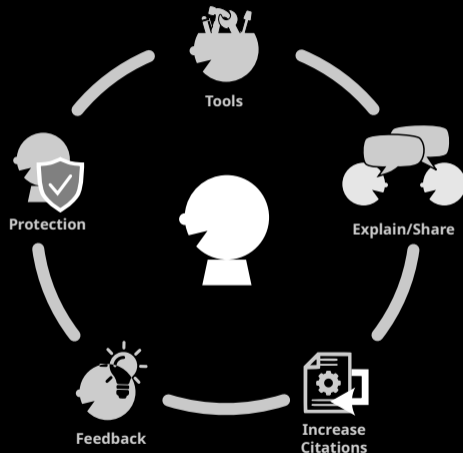
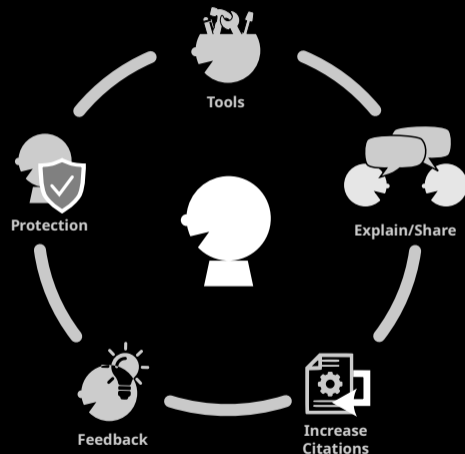[1]**Alston and Rick, Bull Ecol Soc Am, 2020.**   [2]**Piwowar et al., PLoS ONE, 2007.**   [3]**McKiernan et al., eLife, 2016.**
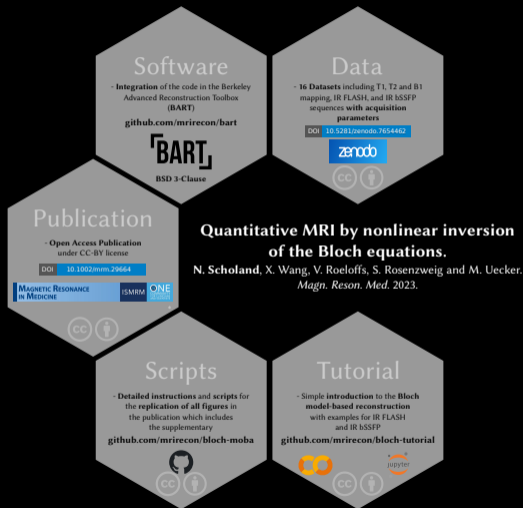
Local Influences of Reproducibility: **Personal**

From Experience:

- Helps me **explain** and **share my work**

- Enables me to quickly and **simply modify analyses** and figures

- Gives me **feedback about errors** and typos in abstracts and publications

Tools

Explain/Share

Increase Citations

Feedback

Protection

Local Influences of Reproducibility: **Example**

Software
- **Integration** of the code in the Berkeley Advanced Reconstruction Toolbox **(BART)**

github.com/mrirecon/bart

BART

BSD 3-Clause

Data
- **16 Datasets** including T1, T2 and B1 mapping, IR FLASH, and IR bSSFP sequences **with acquisition parameters**

DOI 10.5281/zenodo.7654462

zenodo

Publication
- **Open Access Publication** under CC-BY license

DOI 10.1002/mrm.29664

MAGNETIC RESONANCE IN MEDICINE ISMRM ONE

Quantitative MRI by nonlinear inversion of the Bloch equations.
N. Scholand, X. Wang, V. Roeloffs, S. Rosenzweig and M. Uecker.
Magn. Reson. Med. 2023.

Scripts
- **Detailed instructions** and **scripts** for the **replication of all figures** in the publication which includes the supplementary

github.com/mrirecon/bloch-moba

Tutorial
- Simple **introduction** to the **Bloch model-based reconstruction** with examples for IR FLASH and IR bSSFP

github.com/mrirecon/bloch-tutorial

jupyter

- **Focus on building tools**:
  Enhance reusability and sharing

- **Publish software**:
  Regular code reviews and clean-ups

- **Automatization of Figures**:
  Simple modifications for revisions

- **Structure workflow** with script publication in mind (documentation and KISS):
  Simple debugging and sharing

Summary I

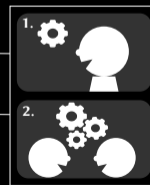There are many reasons for Reproducible Science!

Impact Reduction of personnel fluctuations

Knowledge Distribution

Documentation

Networking & Collaboration

Tools

Explain/Share

Protection

Feedback

Increase Citations

Outline

- Local Influence of Reproducibility

- **Learn About Reproducibility**

- The Reproducibility Day:
  Motivation, Concept and Experiences

The Reproducibility Day

Introduction

Morning Block

Lunch

Afternoon Block

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Social Gathering

1. → **Preproduce** Partners Work

2. → **Feedback** in Groups

Learn About Reproducible Science

Reactive

- Loss of data and documentation

- Long starting periods for new employees

- Difficulties to reproduce others or own work

$\Rightarrow$ Happens too often... $\rightarrow$ **Proactive Learning**

Proactive

- Create internal guidelines/policies

- Regular internal training/event days
  (The Reproducibility Day[1],...)

- Visit events (OSA Info-Day,...)

- Read examples[2] and guidelines[3]

- Attend courses (University, Organizations[4],...)

- **Learn from supervisors, co-authors, and reviewers**

[1]Scholand, Zenodo, 2024   [2]Lasser, Commun. Phys., 2020.   [3]EC2U-RI4C2, D7.3 - Open Science Guidebook   [4]eurodoc: ambassador training

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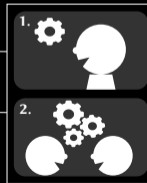

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The Reproducibility Day

Find **fun way** to learn about reproducibility

Focus on **reproducible workflows** not only publications

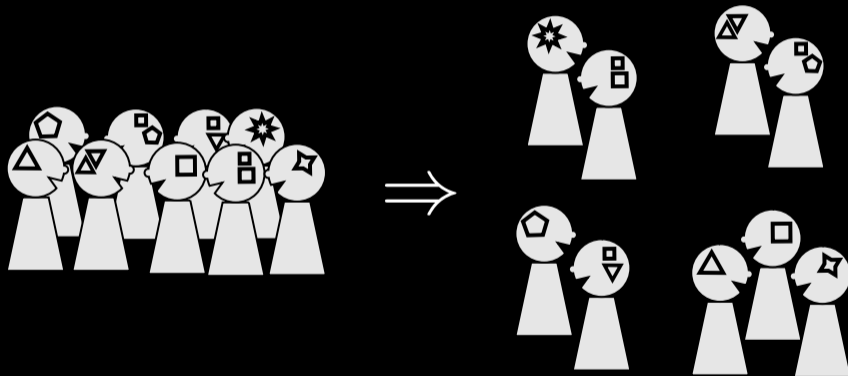Live fire training drills

$\Rightarrow$

Reproducible?

Get in touch regularly!

Test reproducibility of workflows and publications

The Reproducibility Day: **Preparation**

- Assign 2-3 **participants into groups** (ideally: diverse perspectives)

The Reproducibility Day: **Structure**
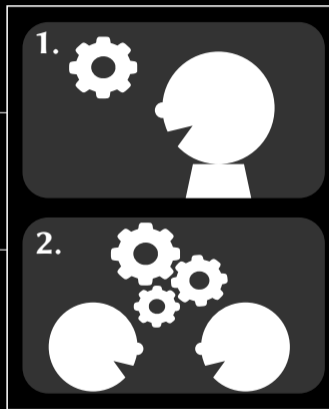

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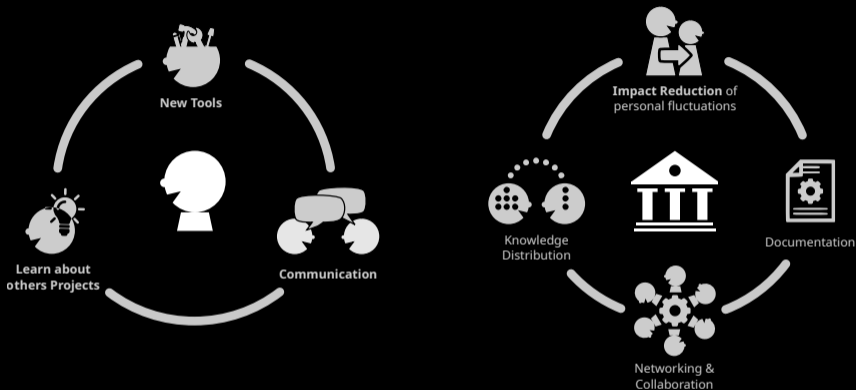**1.**

2.

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The Reproducibility Day: **Experience**

- Five times since 2021 (goal: biannually)

- 10 to 16 participants

- Coordinated over two sites (location in Goettingen and Graz)

- Focus on scientific personnel (PhD students, PostDocs), started to integrate interested
  master students

- Enhance **awareness of benefits of** on-site **reproducibility**

- **Improve internal collaboration** and **knowledge transfer**

- Provide a fun and comfortable atmosphere to learn

The Reproducibility Day: **How to Get Started?**

- **Centralize documentation, code, and data** (Mediawiki, Gitlab groups, NAS/storage server)

- Create summary of local **guidelines** for archiving data, reproducible research practice,...

- Leave participants/groups **freedom** in how they work

- Prepare **social gathering afterwards!**

Summary II

The Reproducibility Day...

- ... is a tool to **experience reproducibility** and learn about its benefits in daily work-flows

- ... gives space to **learn about other projects**, new tools, and to **receive feedback**

- ... **strengthens** the scientific and social **connections** in the group

- ... **improves internal collaborations**, **documentation** and **individual developments** of the participant

$\rightarrow$ Became a **valuable tool** for our research group

Appendix

Rough General Guidelines

Documentation

- The **idea** of the project needs to be **well described**
- **Scripts**, **data**, and **lab notes** need to be easily **accessible** (no private accounts/repos)
- All **references** in the documentation (hyperlinks, git commits, archive paths) should be **valid**
- **Publication results are reproducible**; its tools, scripts, manuscripts, and software versions sufficiently documented

Code

- **Comments** are **useful** and understandable
- **Dependencies** are **documented**
- Ideally **code** is **easily executable** and transferable

Common Challenges

- **Inaccessible links** (private GitRepos,...)

- **Different operating systems** challenging (virtual machines)

- **Proprietary software** and licenses

- Incorrect **rights management** of archived projects

Parts can be compensated with
technical introduction meeting
prior to the event