Varieties of Reproducibility

in Empirical and Computational Domains

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http://olivia.science

Workshop on Reproducibility in Machine Learning

RML@ICML 2018

computational cognitive neuroscience

cognitive modelling

computer science

psychology, neuroscience, cognitive science

Ph.D. reproducing comp models

Reproducibility

How Many Random Seeds? Statistical Power Analysis in Deep Reinforcement Learning Experiments. Colas, Sigaud, Oudeyer. 2018. https://arxiv.org/abs/1806.08295

Lessons Learned Reproducing a Deep Reinforcement Learning Paper. Rahtz. 2018.
http://amid.fish/reproducing-deep-rl

Deep Reinforcement Learning Doesn't Work Yet. Irpan. 2018. https://www.alexirpan.com/2018/02/14/rl-hard.html

Deep Reinforcement Learning that Matters. Henderson, Islam, Bachman, Pineau, Precup, Meger. 2017.
https://arxiv.org/abs/1709.06560

Talk Outline

What is reproducibility? Why is it important?

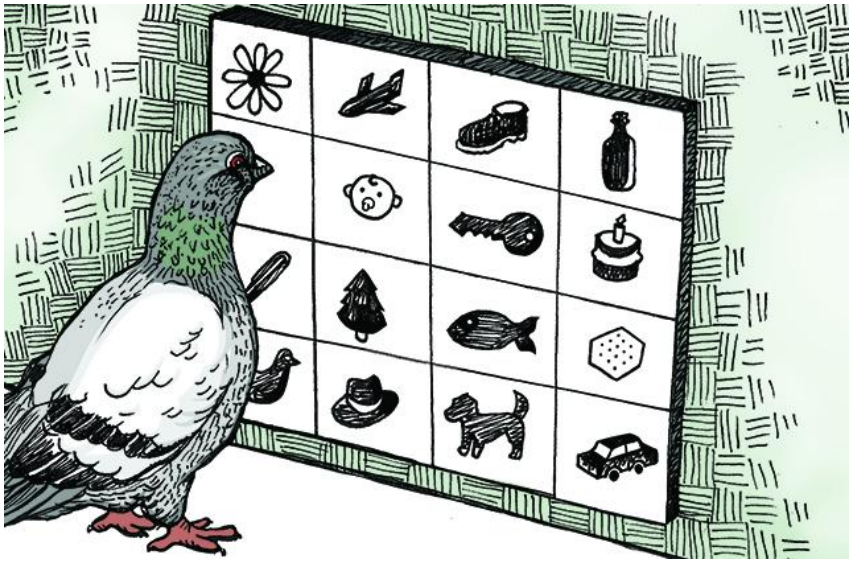
Talk Outline

What is reproducibility? Why is it important?

How can we achieve it?

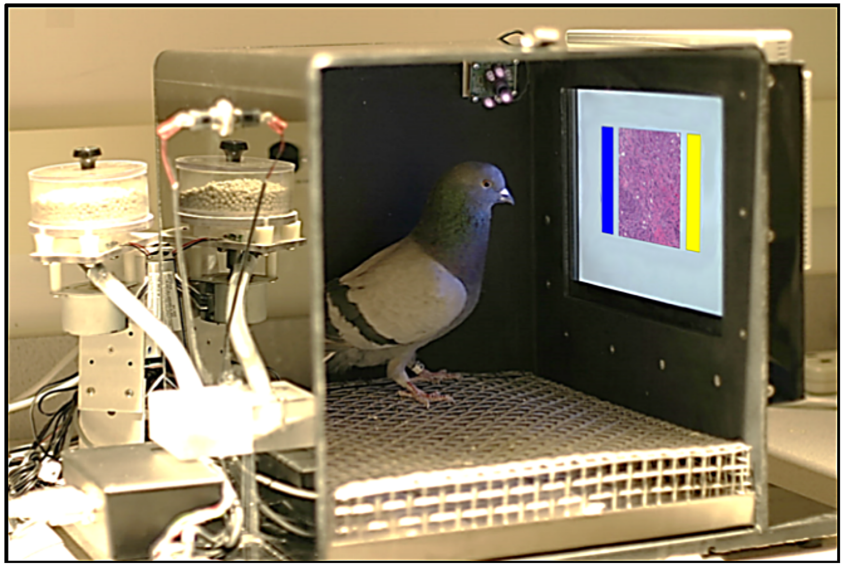
What is reproducibility?

running the same experiment and getting the same* results in the same lab



What is reproducibility?

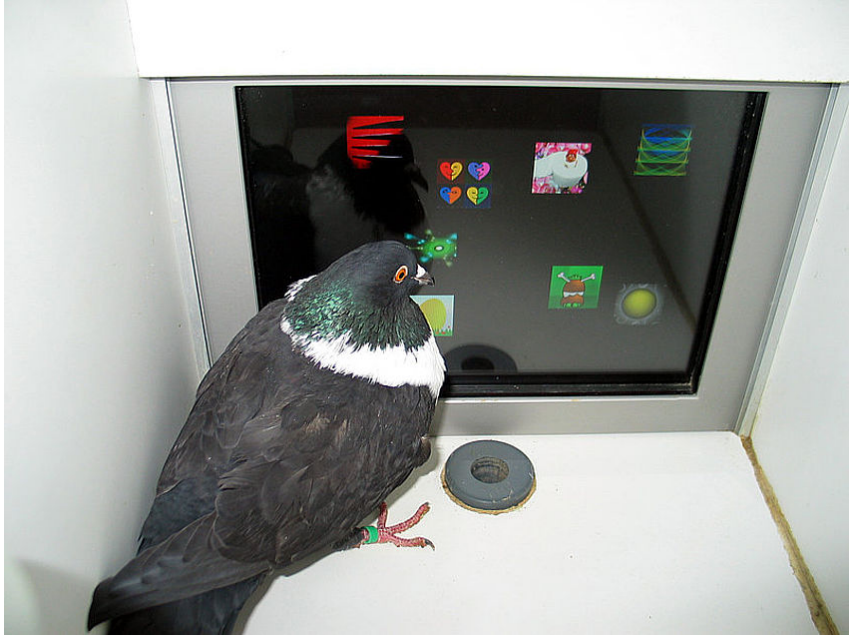
running the same experiment and getting the same* results in a *different* lab



Levenson RM, Krupinski EA, Navarro VM, Wasserman EA (2015) Pigeons (Columba livia) as Trainable Observers of Pathology and Radiology Breast Cancer Images. PLOS ONE 10(11): e0141357. https://doi.org/10.1371/journal.pone.0141357

What is reproducibility?

running the same or conceptually similar experiment and getting the same* results *under slightly different conditions*



https://cogbio.univie.ac.at/research/research-groups/pigeon-lab/

What is reproducibility?

Software Sustainability Institute

running the same code and getting the same* results on the same machine

BETTER SOFTWARE BETTER RESEARCH

What is reproducibility?

Software Sustainability Institute

running the same code and getting the same* results on a *different* machine

BETTER SOFTWARE BETTER RESEARCH

What is reproducibility?

Software Sustainability Institute

running the same code and getting the same* results *after 3 years*; *after updating libraries*; etc.

BETTER SOFTWARE BETTER RESEARCH

What is reproducibility?

Software Sustainability Institute

time- and machine-independent code

BETTER SOFTWARE BETTER RESEARCH

What is reproducibility?

Software Sustainability Institute

But what about time- and machine-independent understanding, ideas, theories?

BETTER SOFTWARE BETTER RESEARCH

Reproducible and replicable CFD: it's harder than you think, Olivier Mesnard, Lorena A. Barba. IEEE/AIP Computing in Science and Engineering, 19(4):44–55 (2017). 10.1109/MCSE.2017.3151254

What is reproducibility?

What about software, a model, being reproducible given a *theory* or *specification*?

What is reproducibility?

If we use a model to demonstrate a theory then the theory should be enough to recreate the model…

What is reproducibility?

Type 1: software people predominantly care about code being time- and machine-independent

What is reproducibility?

Type 2: scientists/modellers also care about the specification.

What is reproducibility?

Type 2: can software written based on the article capture the theory?

What is reproducibility?

Specification
$\neq$
comments

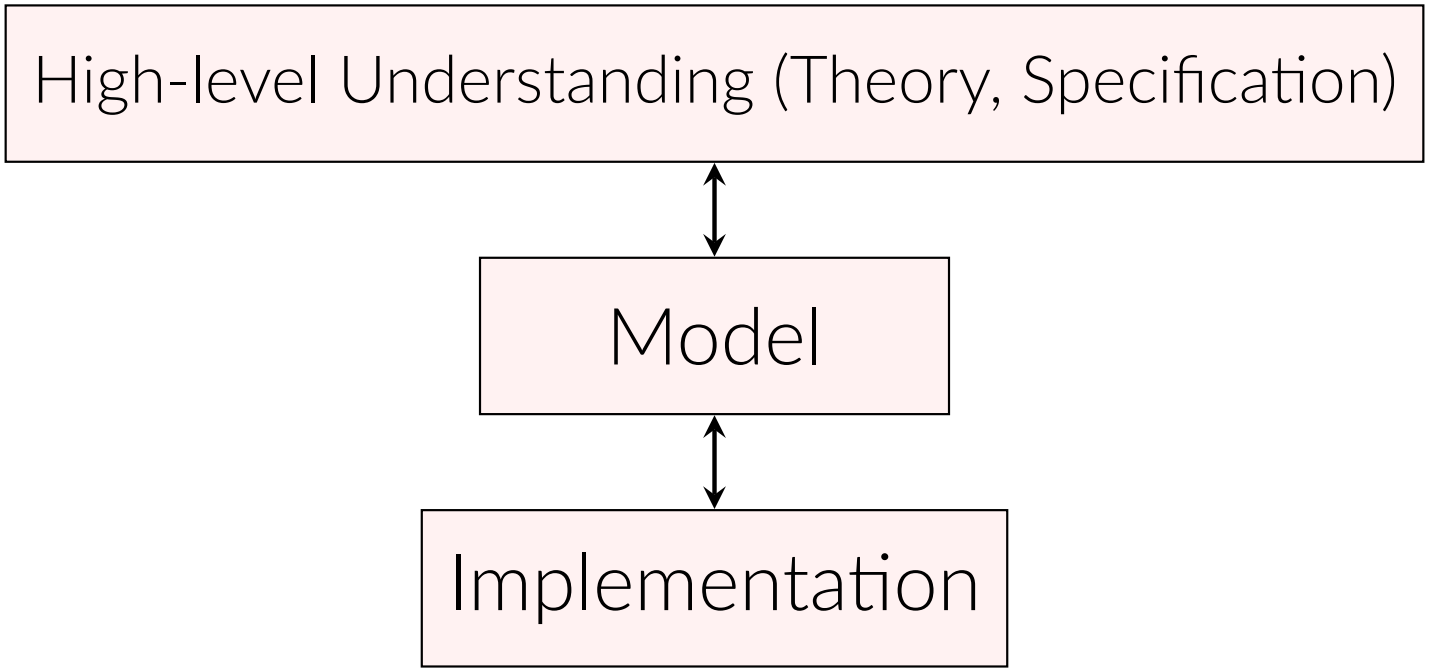
What is reproducibility?

Specification
$\neq$
documentation

What is reproducibility?

Specification
$\neq$
code

Why is reproducibility important?



Cooper, R. P. & Guest, O. (2014). **Implementations are not specifications: specification, replication and experimentation in computational cognitive modeling**. Cognitive Systems Research. doi: 10.1016/j.cogsys.2013.05.001.

Classical Mechanics

LAW I.

Every body perſeveres in its ſtate of reſt, or of uniform motion in a right line, unleſs it is compelled to change that ſtate by forces impreſs'd thereon.

LAW II.

The alteration of motion is ever proportional to the motive force impreſs'd; and is made in the direction of the right line in which that force is impreſs'd.

LAW III.

To every Action there is always oppoſed an equal Reaction: or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.

Motte (1729)

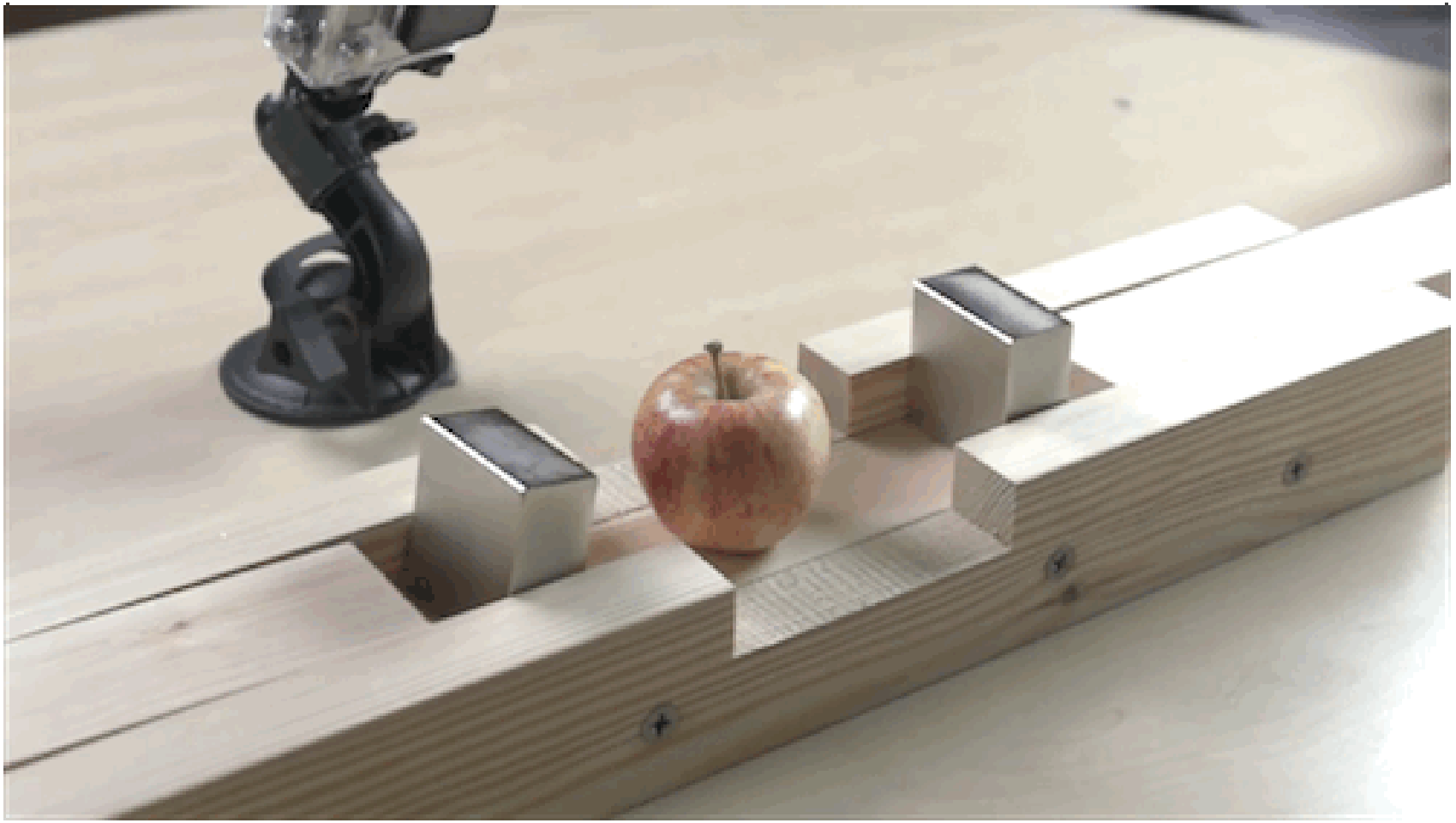
Classical Mechanics

$$\sum \mathbf{F} = 0 \;\Leftrightarrow\; \frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t} = 0$$

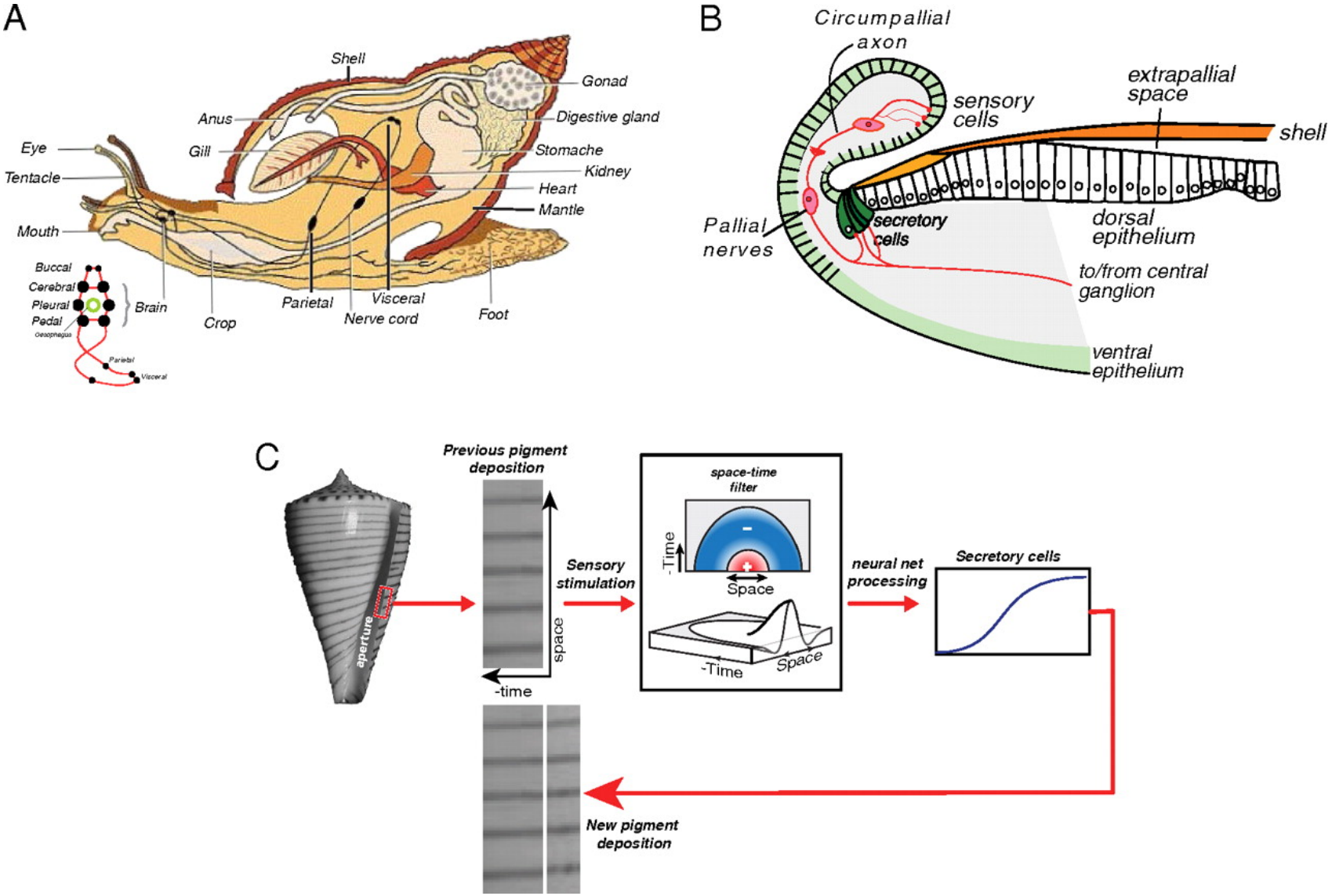
$$\mathbf{F} = m\,\frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t} = m\mathbf{a}$$

$$\mathbf{F}_A = -\mathbf{F}_B$$

Classical Mechanics

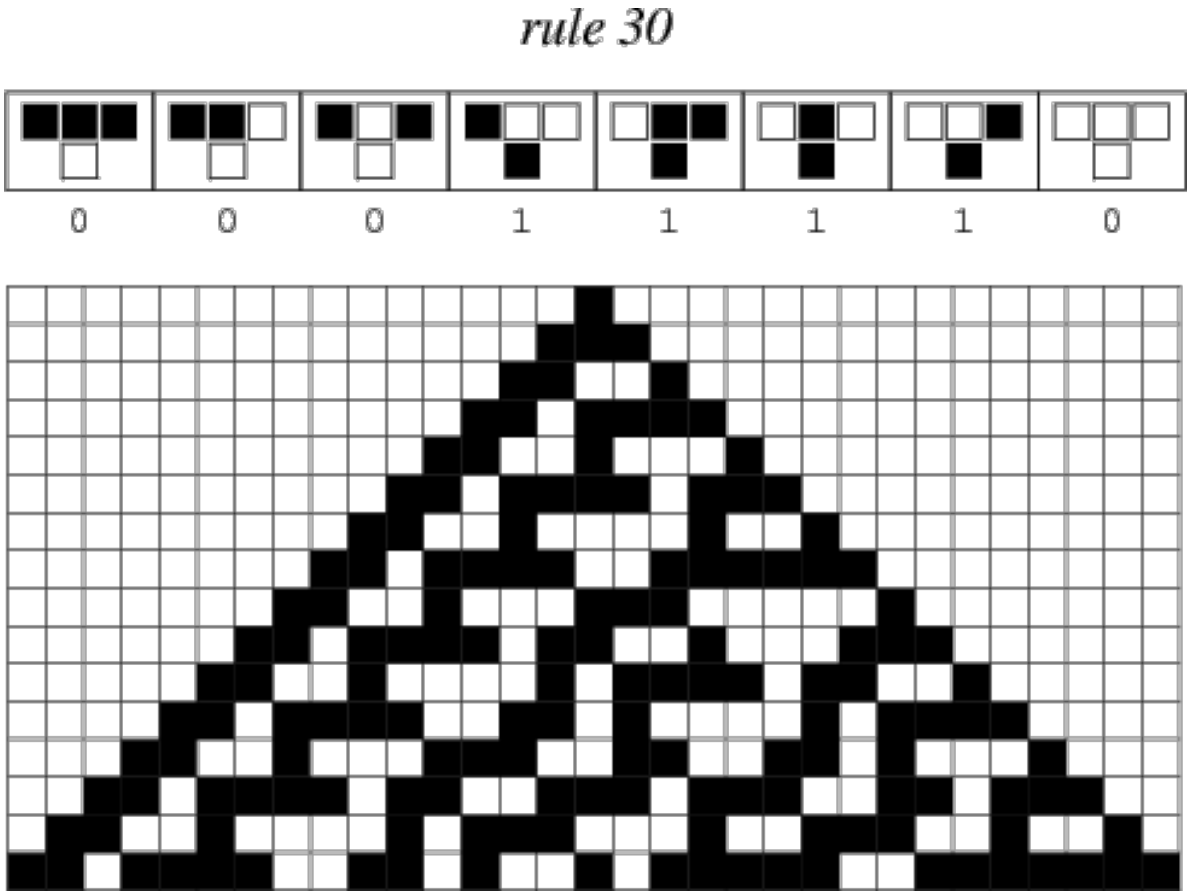


Cellular Automata



Evolution of patterns on Conus shells Zhenqiang Gong, Nichilos J. Matzke, Bard Ermentrout, Dawn Song, Jann E. Vendetti, Montgomery Slatkin, George Oster Proceedings of the National Academy of Sciences Jan 2012, 109 (5) E234-E241; DOI: 10.1073/pnas.1119859109

Cellular Automata



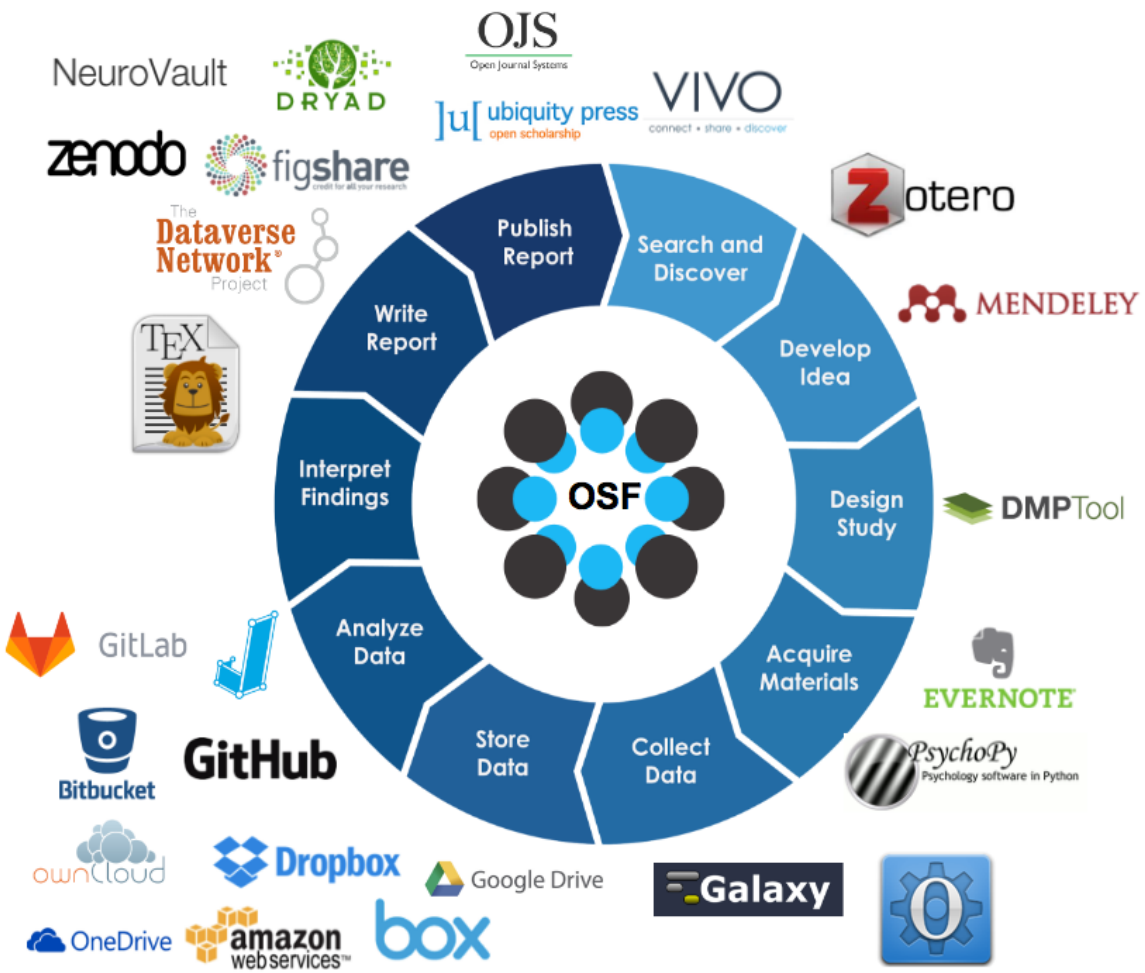
Weisstein, Eric W. "Rule 30." From MathWorld—A Wolfram Web Resource.
http://mathworld.wolfram.com/Rule30.html

Didier Descouens CC BY-SA 3.0

left XOR (centre OR right)

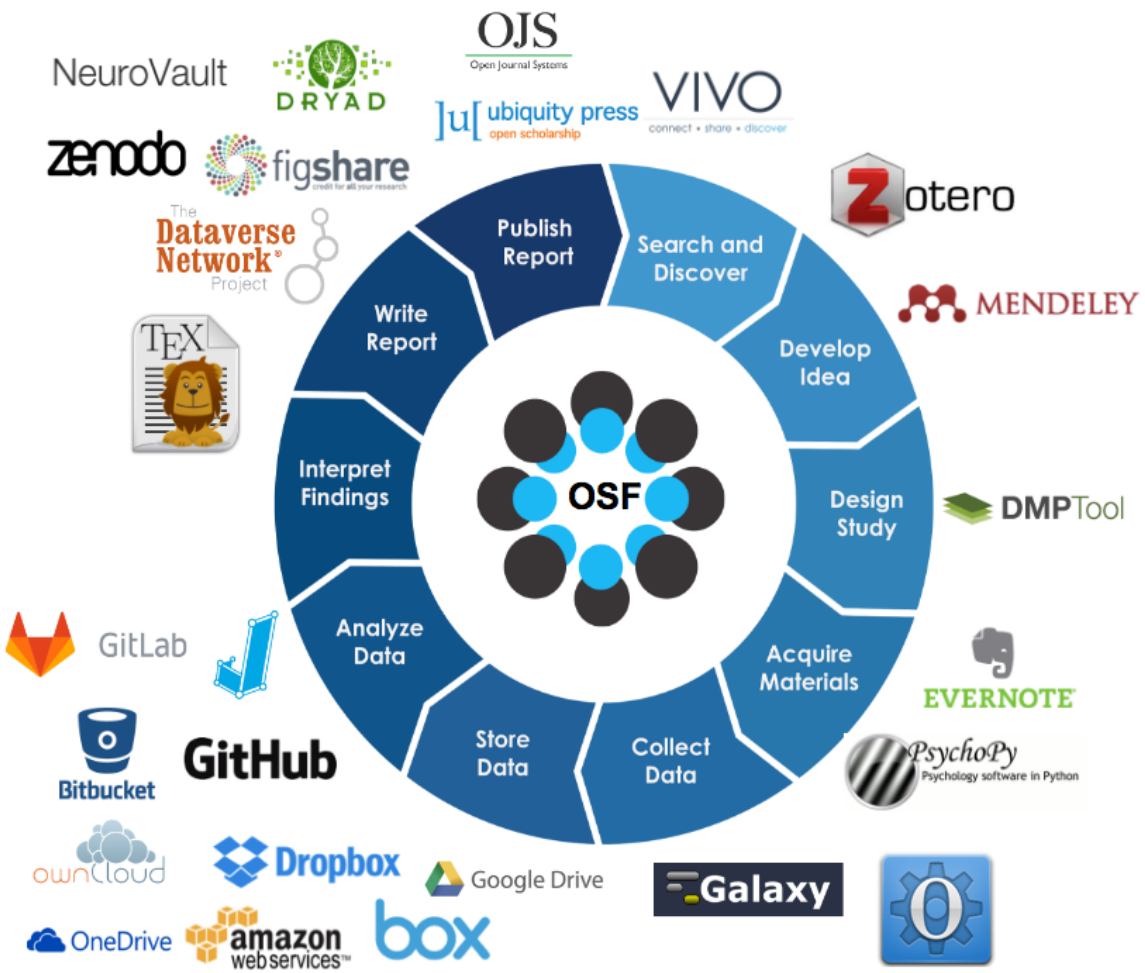
Achieving reproducibility

Share code



Achieving reproducibility

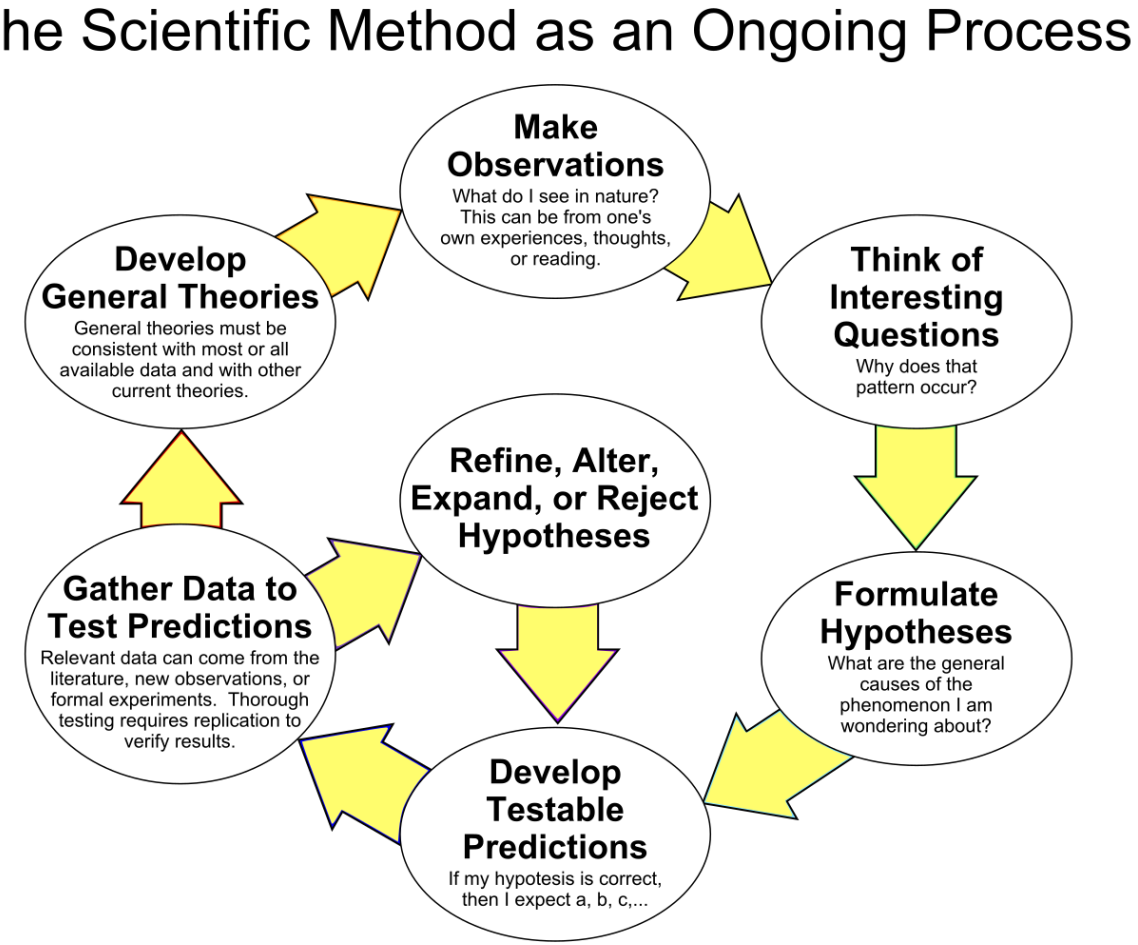
Share code, share data… but not enough!



Achieving reproducibility

Write stuff up well!

ReScience



Whatiguana and ArchonMagnus, CC BY-SA 4.0

Rougier, N. P. et al. (2017). **Sustainable computational science: the ReScience initiative**. PeerJ Computer Science. doi: 10.7717/peerj-cs.142.

Guest, O. & Rougier, N. P. (2016). **Dialogue: What is Computational Reproducibility?**. IEEE CIS Newsletter on Cognitive and Developmental Systems. 13 (2).

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Thank you!

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