

Extracting Sunbeams Out of Cucumbers:

Why Archaeology Isn't a Science,
and How It Can Become One

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Summer School "Reproducible Research In Landscape Archaeology" by
the Excellence Cluster Topoi, Freie Universität Berlin, the Collaborative
Research Centre 1266 "Scales of Transformation: Human-Environmental
Interaction in Prehistoric and Archaic Societies" and Christian-Albrechts-
Universität zu Kiel.

1. What is a science, these days?

What philosophers say, what scientists say, what archaeologists say

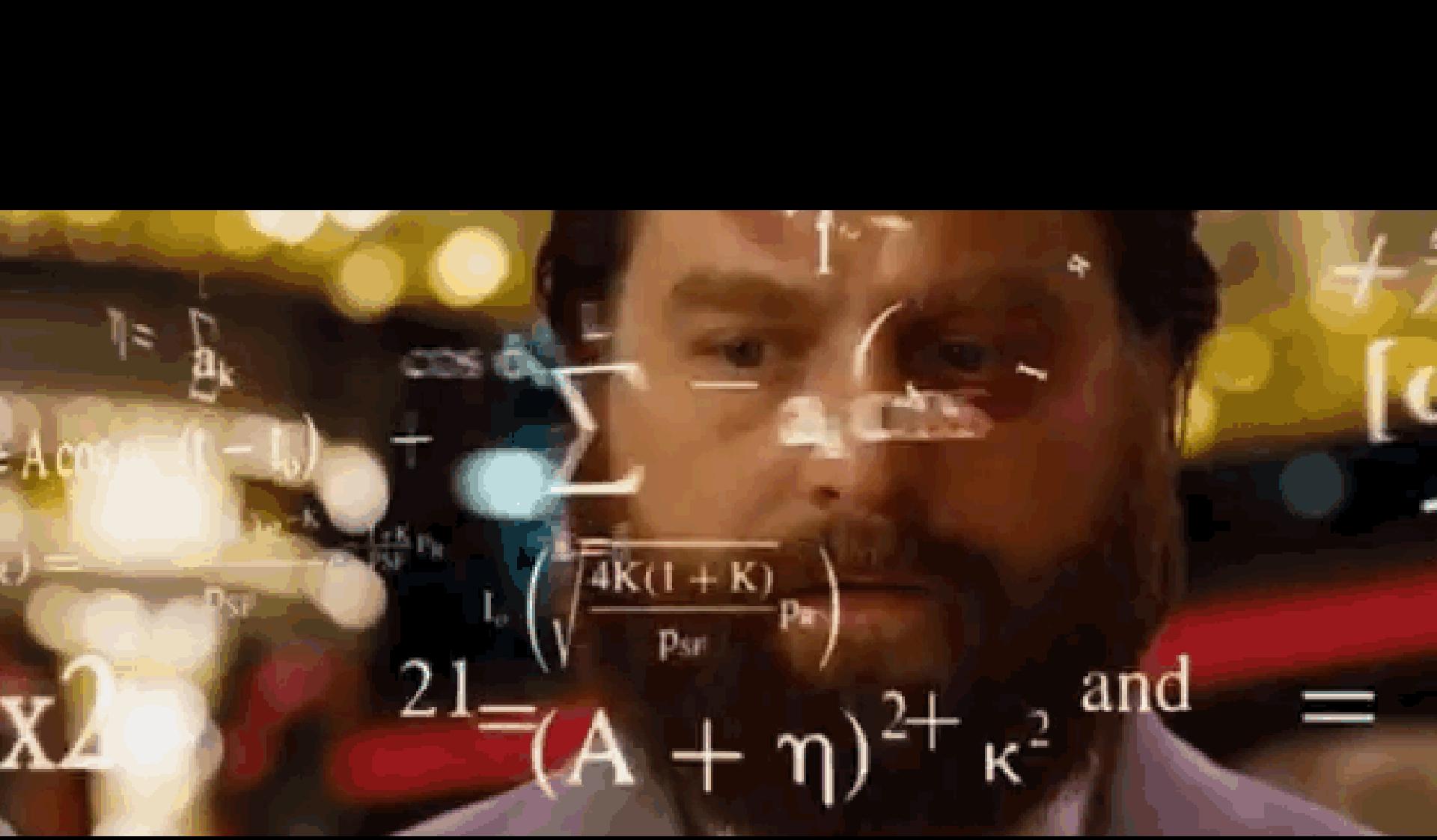
2. Why isn't archaeology a science?

What do archaeologists do?

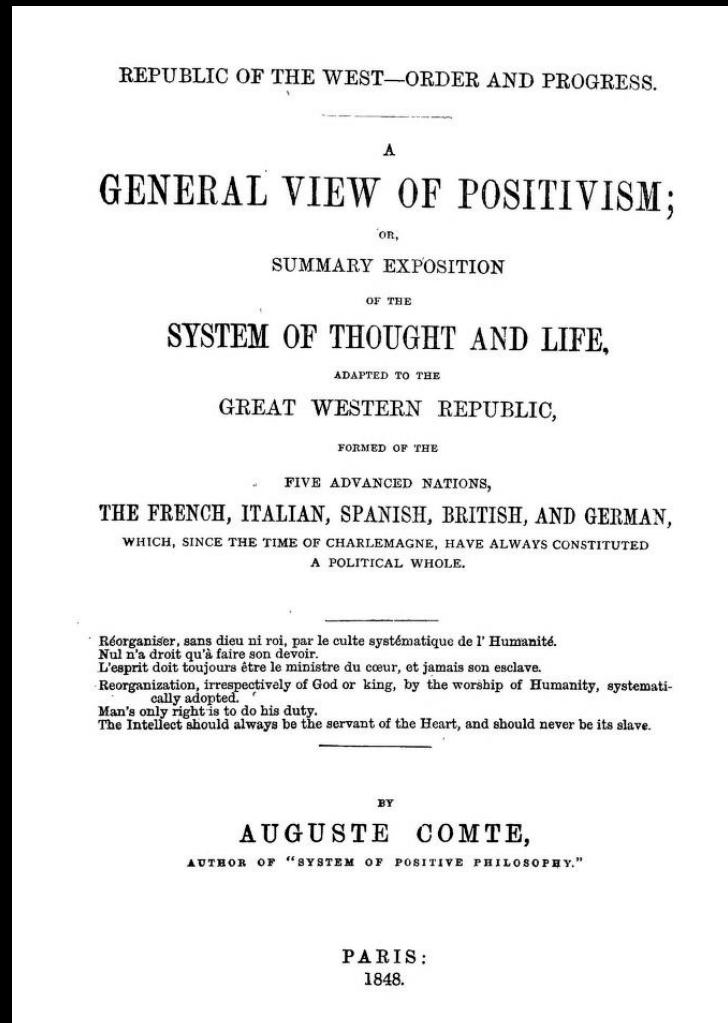
3. How to be a science

What archaeologists can do to become a community of scientific researchers

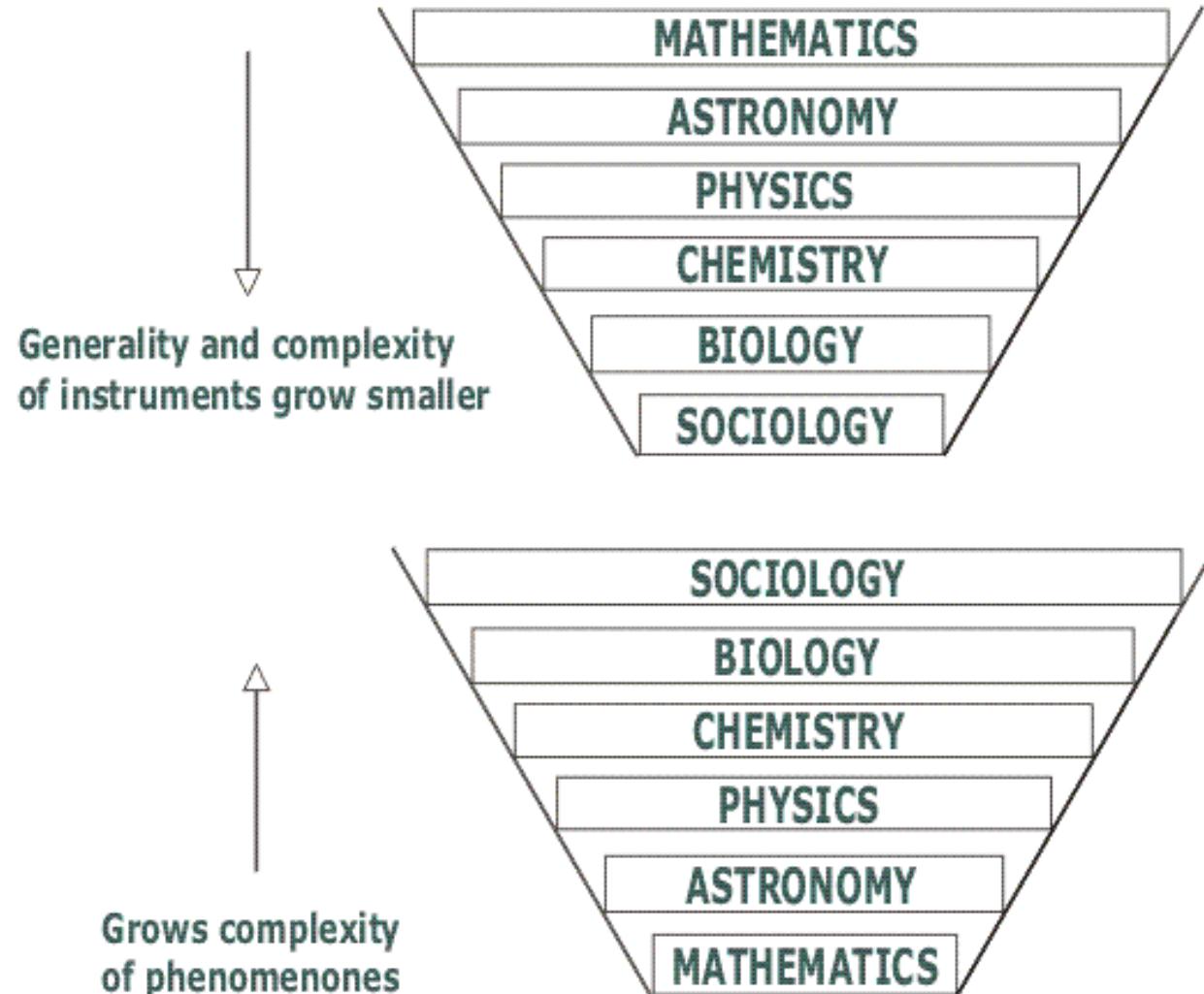
What is
a
science



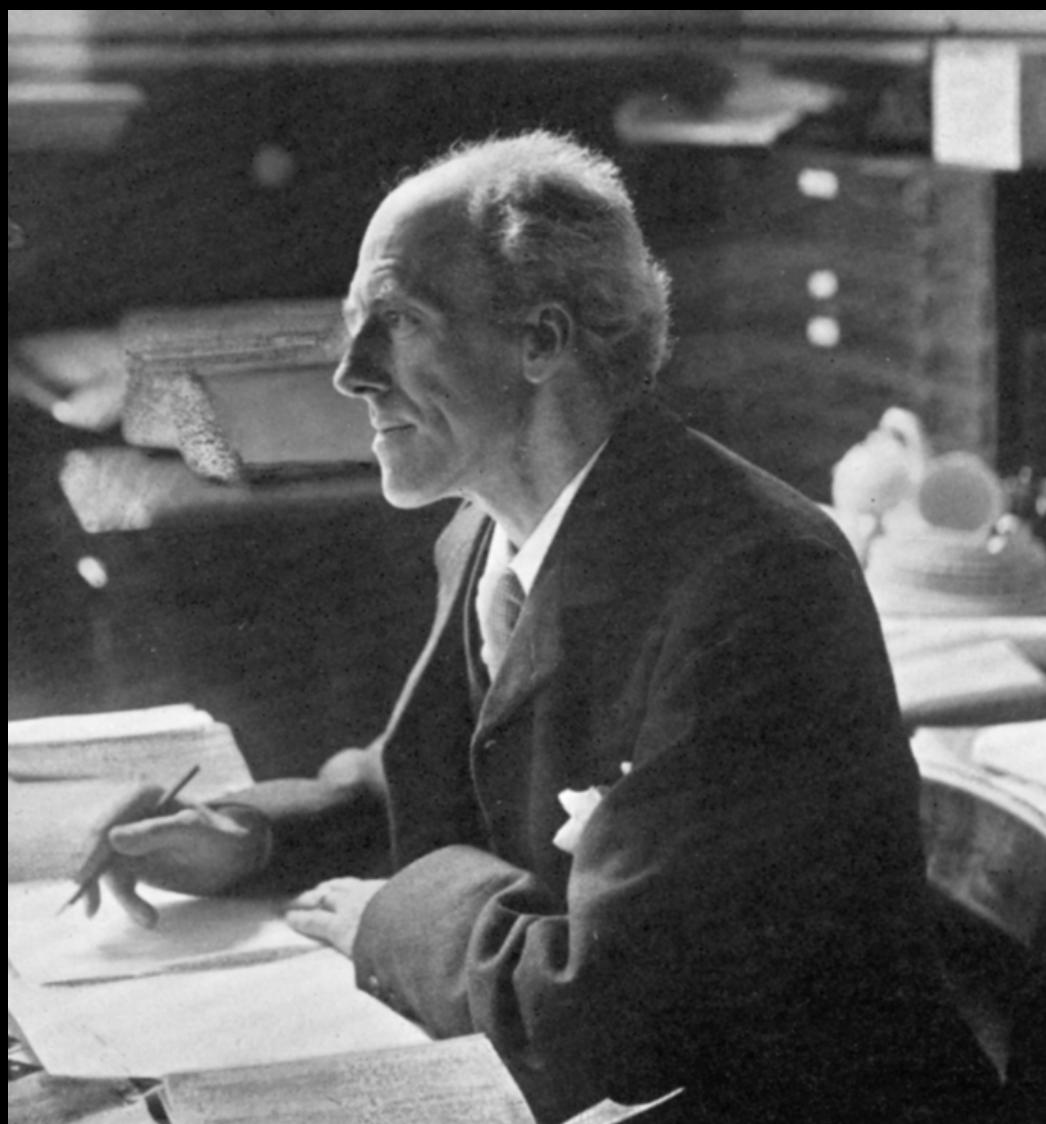
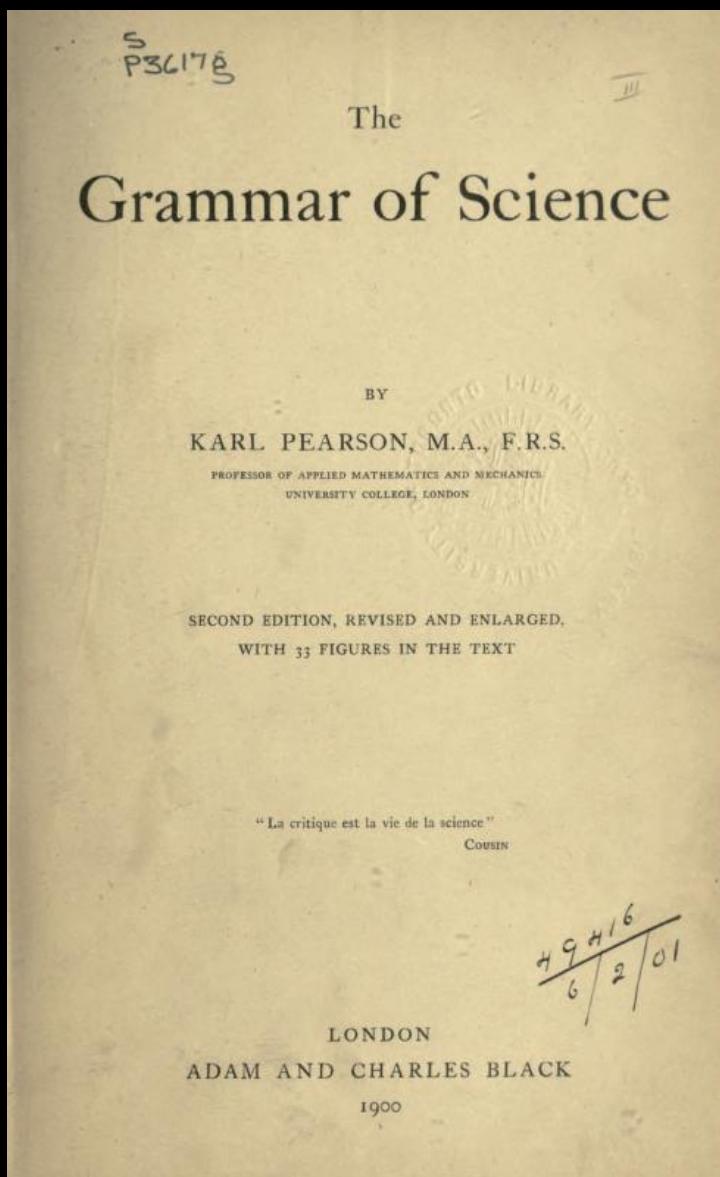
Principle	Science	Non-/pseudoscience	Author, [ref]
positivism	reached the positive stage: builds knowledge on empirical data	still in theological or meta-physical stages: phenomena are explained by recurring to deities or non-observables entities	Comte 1830 [5]



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Principle	Science	Non-/pseudoscience	Author, [ref]
methodologism	follows rigorous methods for selecting hypotheses, acquiring data, and drawing conclusions	fails to follow the scientific method	e.g. Pearson 1900, Poincare 1914 [6][7]



Principle	Science	Non-/pseudoscience	Author, [ref]
verificationism	builds upon verified statements	relies on non-verifiable statements	Wittgenstein 1922 [8]



Tractatus
Logico-Philosophicus

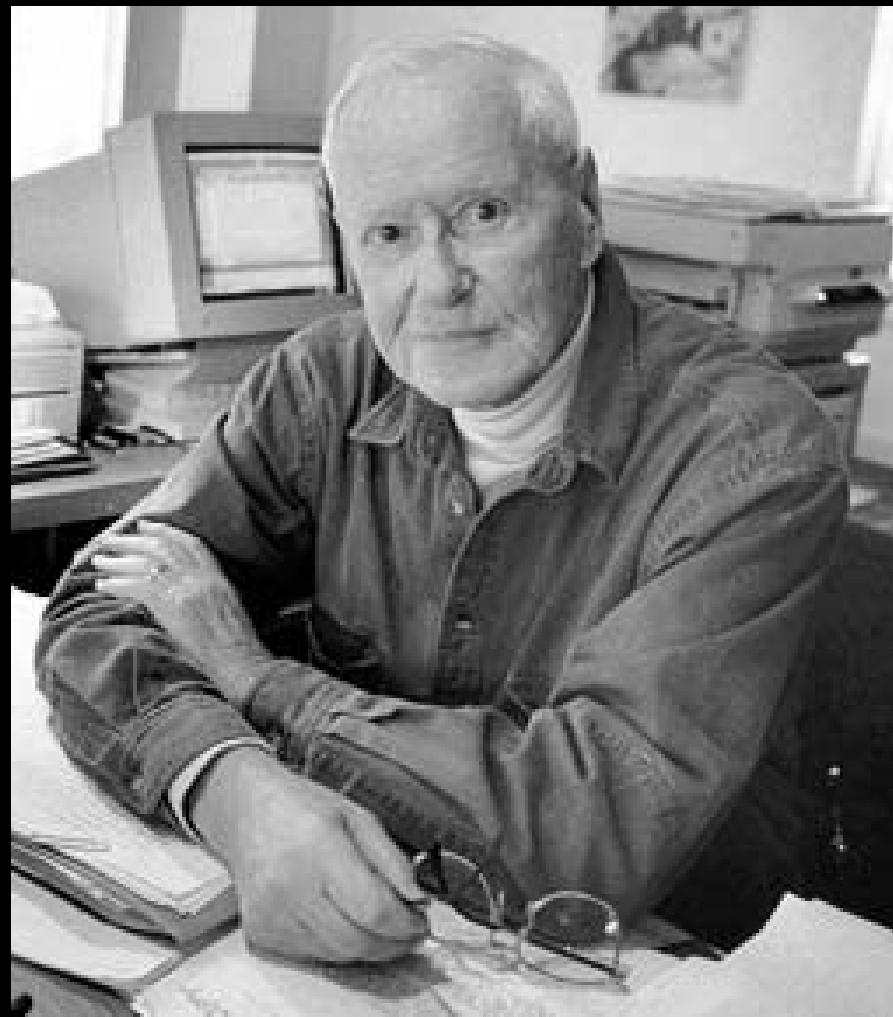
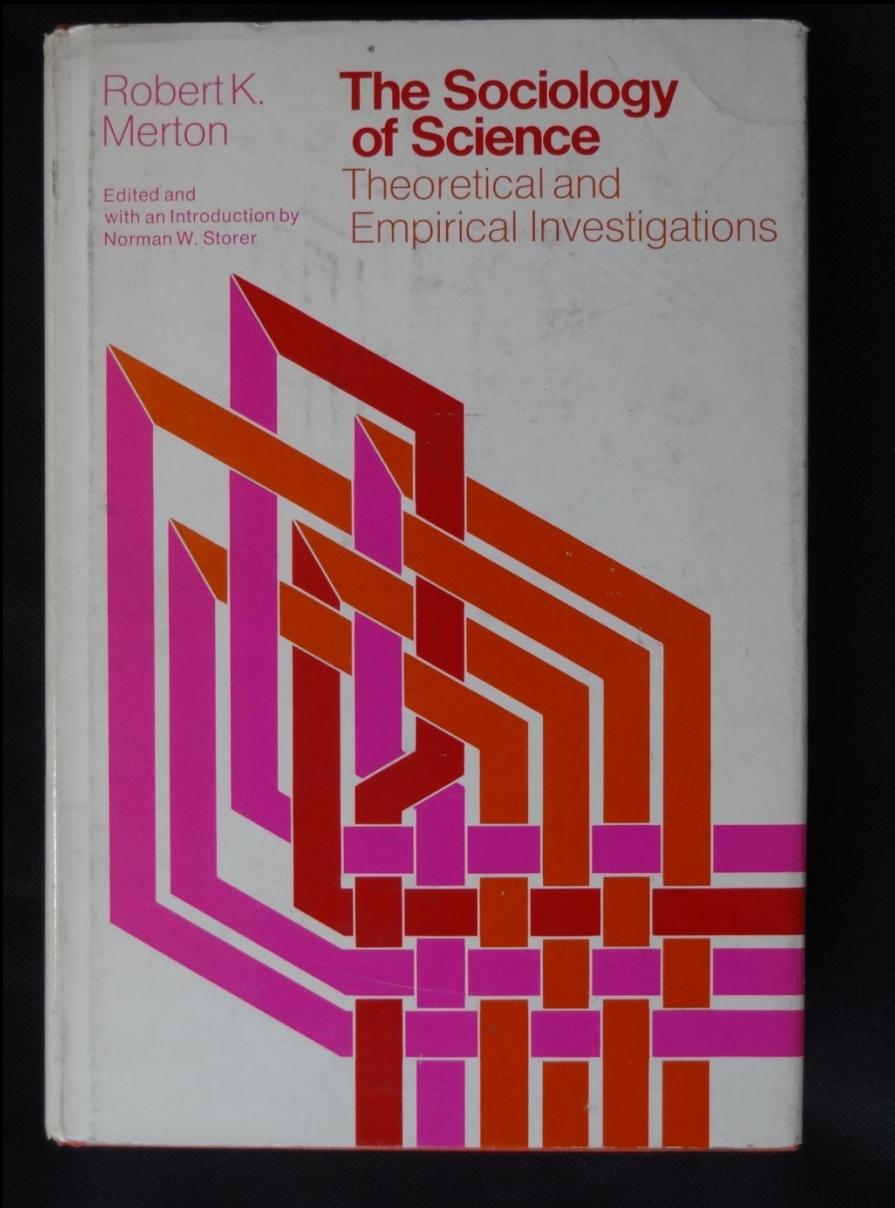
By
LUDWIG WITTGENSTEIN

With an Introduction by
BERTRAND RUSSELL, F.R.S.

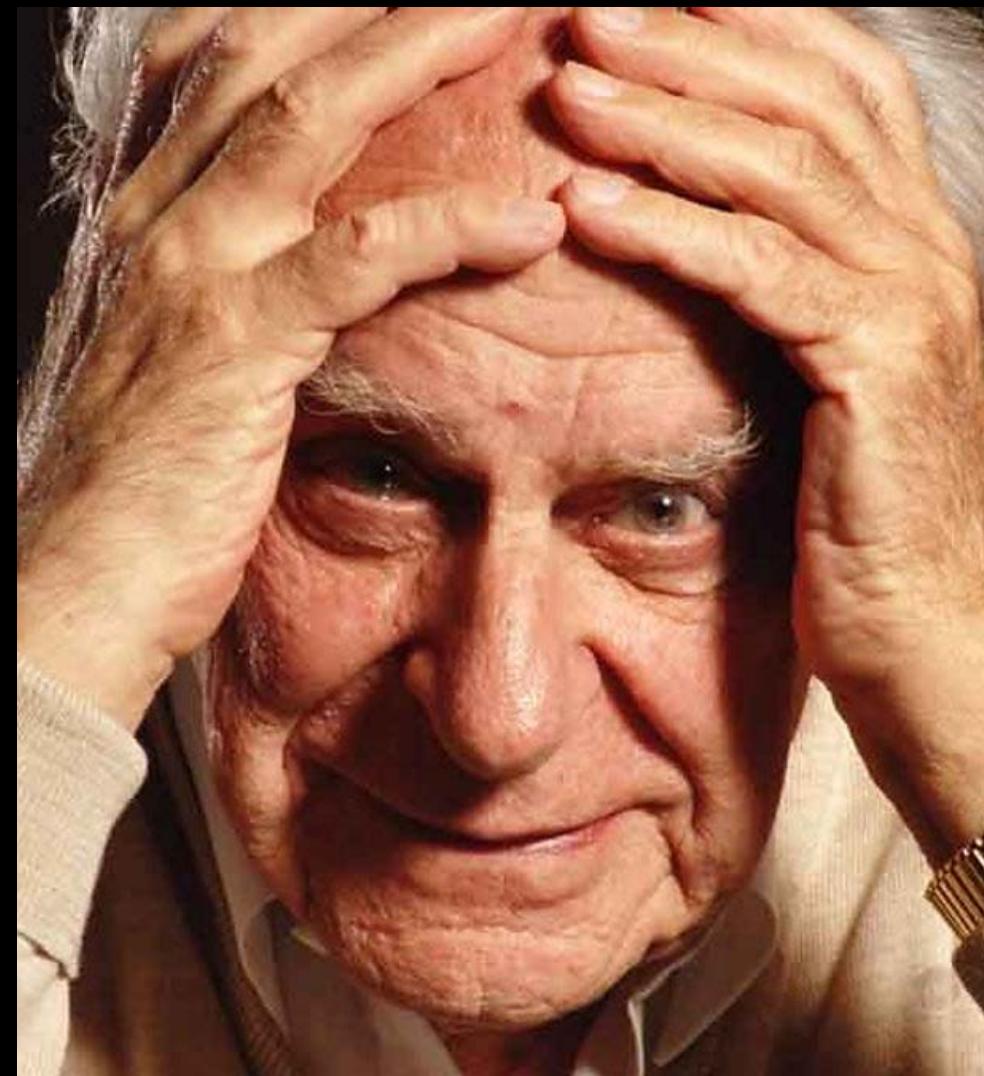


NEW YORK
HARCOURT, BRACE & COMPANY, INC.
LONDON: KEGAN PAUL, TRENCH, TRUBNER & CO., LTD.
1922

Principle	Science	Non-/pseudoscience	Author, [ref]
norms	follows four fundamental norms, namely: universalism, communism, disinterestedness, organized scepticism	operates on different, if not the opposite, sets of norms	Merton 1942 [11]



Principle	Science	Non-/pseudoscience	Author, [ref]
falsificationism	builds upon falsifiable, non-falsified statements	produces explanations devoid of verifiable counterfactuals	Popper 1959 [9]



Principle	Science	Non-/pseudoscience	Author, [ref]
methodological falsificationism	generates theories of increasing empirical content, which are accepted when surprising predictions are confirmed	protects its theories with a growing belt of auxiliary hypotheses, giving rise to “degenerate” research programs	Lakatos 1970 [10]



Falsification and the Methodology of Scientific Research Programmes¹

IMRE LAKATOS
London School of Economics

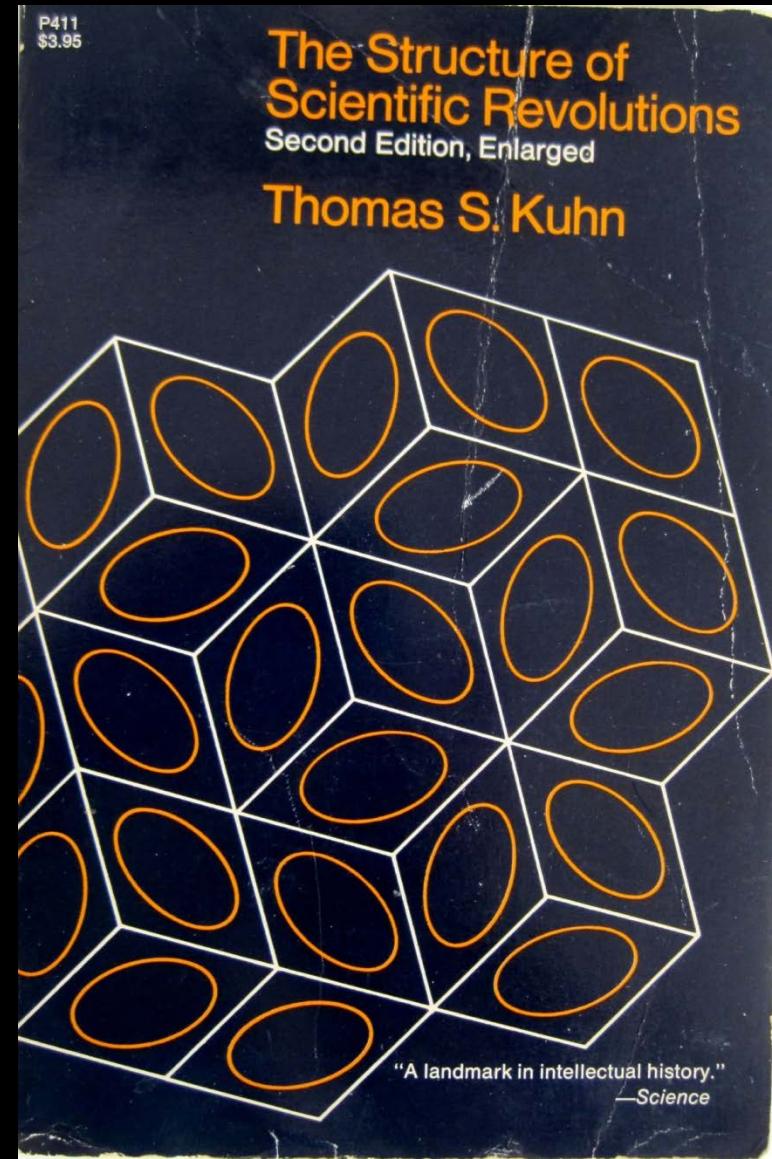
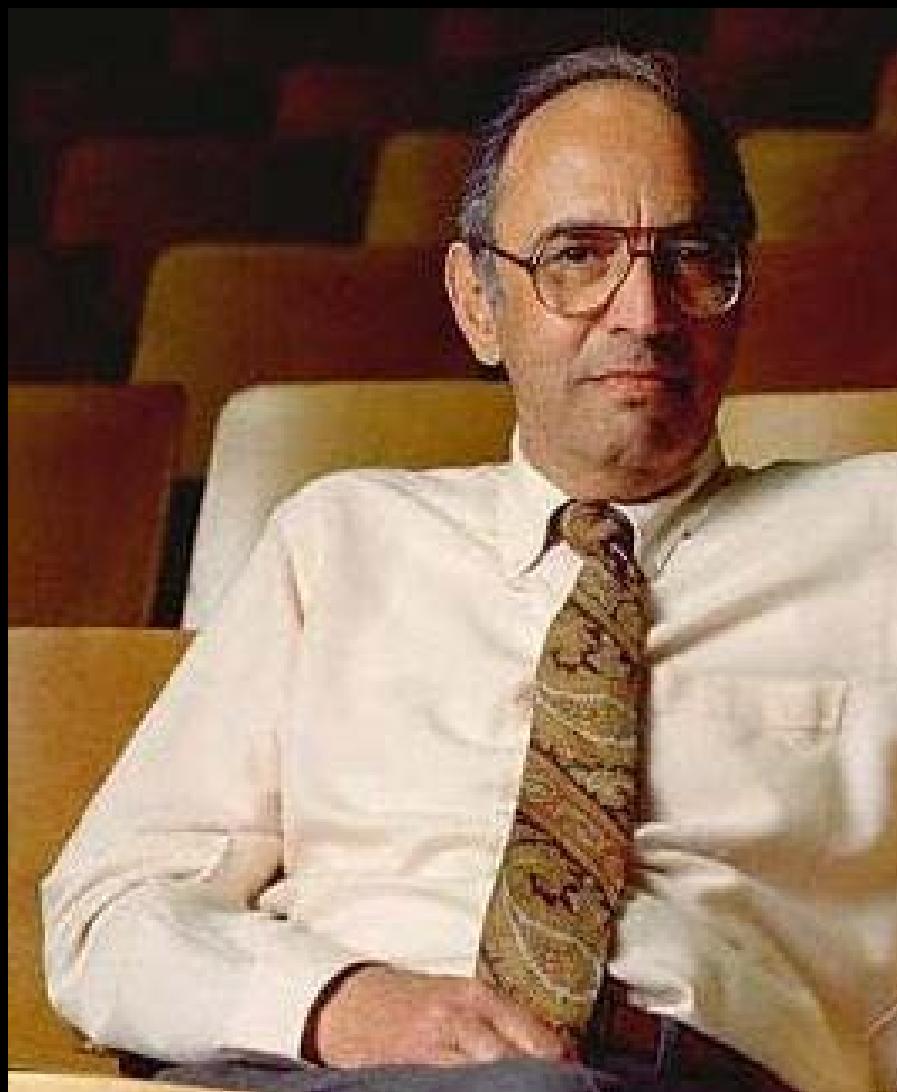
1. *Science: reason or religion?*
2. *Fallibilism versus falsificationism.*
 - (a) *Dogmatic (or naturalistic) falsificationism. The empirical basis.*
 - (b) *Methodological falsificationism. The ‘empirical basis’.*
 - (c) *Sophisticated versus naive falsificationism. Progressive and degenerating problemshifts.*
3. *A methodology of scientific research programmes.*
 - (a) *Negative heuristic; the ‘hard core’ of the programme.*
 - (b) *Positive heuristic; the construction of the ‘protective belt’ and the relative autonomy of theoretical science.*
 - (c) *Two illustrations: Prout and Bohr.*
 - (c1) *Prout: a research programme progressing in an ocean of anomalies.*
 - (c2) *Bohr: a research programme progressing on inconsistent foundations.*
 - (d) *A new look at crucial experiments: the end of instant rationality.*
 - (d1) *The Michelson–Morley experiment.*
 - (d2) *The Lummer–Pringsheim experiments.*
 - (d3) *Beta-decay versus conservation laws.*
 - (d4) *Conclusion. The requirement of continuous growth.*
4. *The Popperian versus the Kuhnian research programme.*
Appendix: Popper, falsificationism and the ‘Duhem–Quine thesis’.

I. SCIENCE: REASON OR RELIGION?

For centuries knowledge meant proven knowledge—proven either by the power of the intellect or by the evidence of the senses. Wisdom and intellectual integrity demanded that one must desist from unproven utterances and minimize, even in thought, the gap between speculation and established knowledge. The proving power of the intellect or the senses was

¹ This paper is a considerably improved version of my [1968b] and a crude version of my [1973]. Some parts of the former are here reproduced without change with the permission of the Editor of the *Proceedings of the Aristotelian Society*. In the preparation of the new version I received much help from Tad Beckman, Colin Howson, Clive Kilmister, Larry Laudan, Eliot Leader, Alan Musgrave, Michael Sukale, John Watkins and John Worrall.

Principle paradigm	Science	Non-/pseudoscience	Author, [ref]
	is post-paradigmatic, meaning it: solves puzzles defined and delimited by the rules of an accepted paradigm	is pre-paradigmatic: lacks a unique and unifying intellectual framework or is fragmented into multiple competing paradigms	Kuhn 1974 [12]



But these approaches have limited practical value



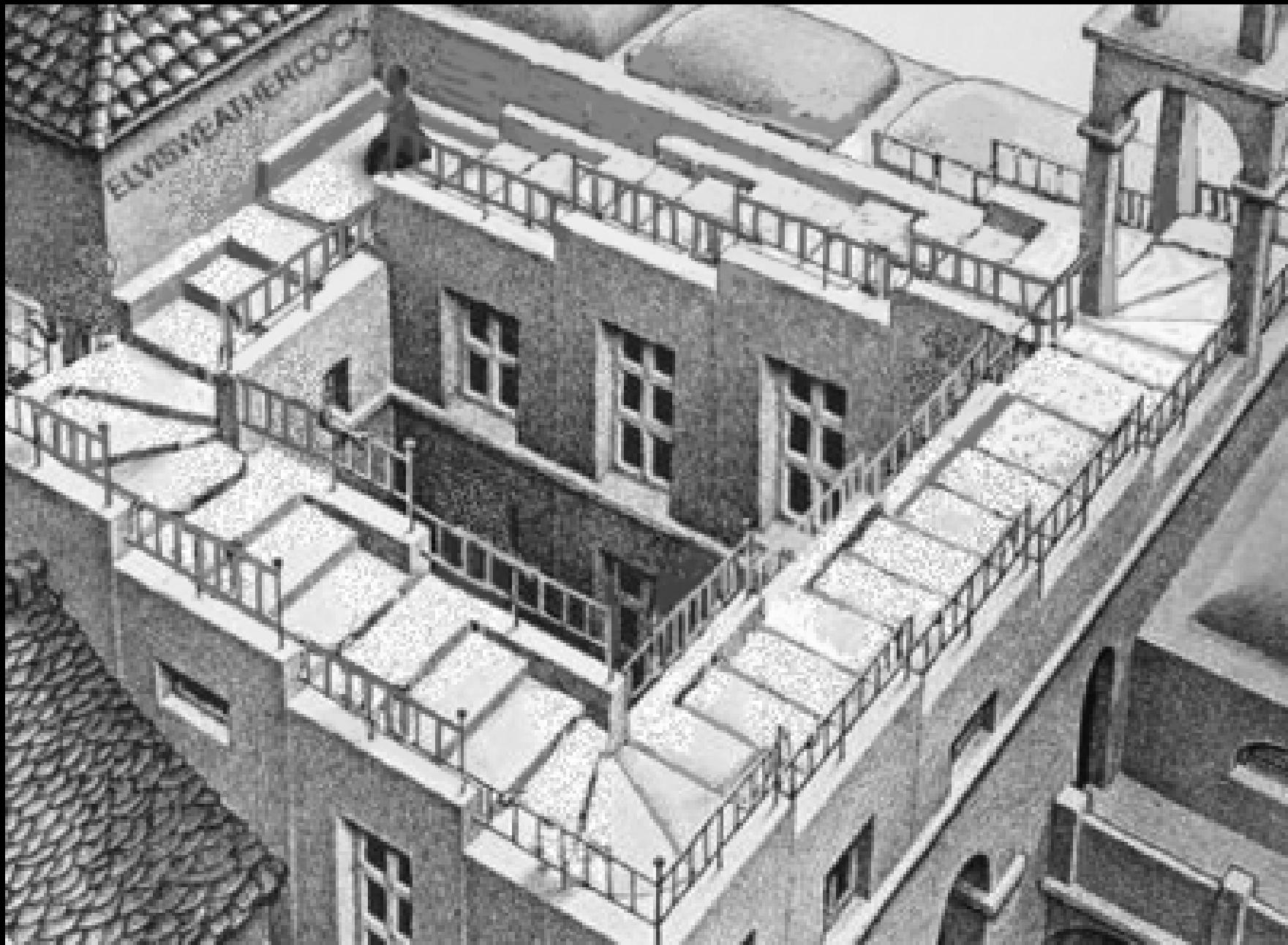
But these approaches have limited practical value

- a research program (Lakatos)
- an epistemic field or cognitive discipline (Bunge)
- a theory (Popper)
- a practice (Lugg; Morris)
- a scientific problem or question (Siitonens)
- a particular inquiry (Kuhn; Mayo)

- individual
- group
- institute
- discipline

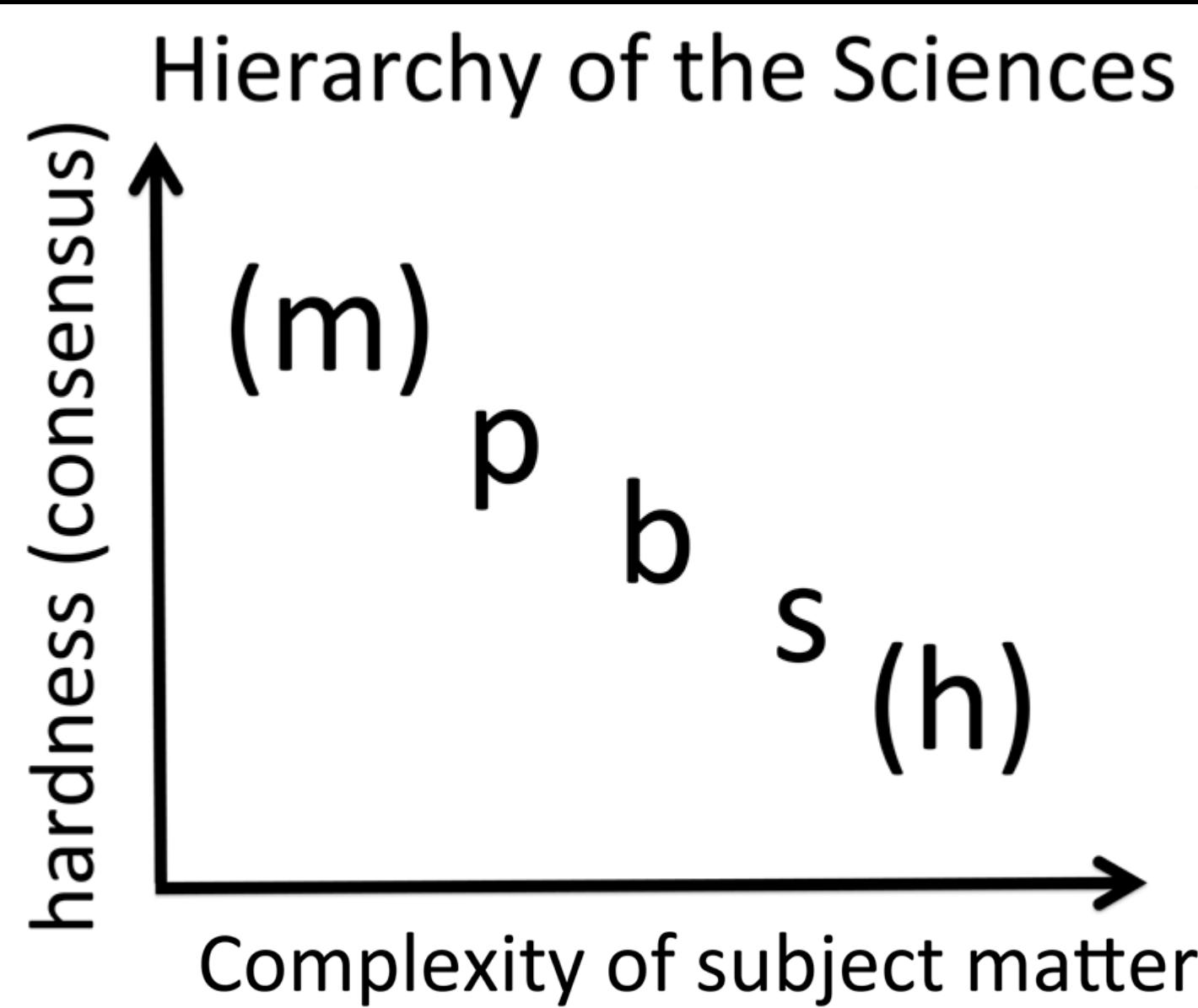


The demarcation paradox





How can we be scientific about scientific demarcation?



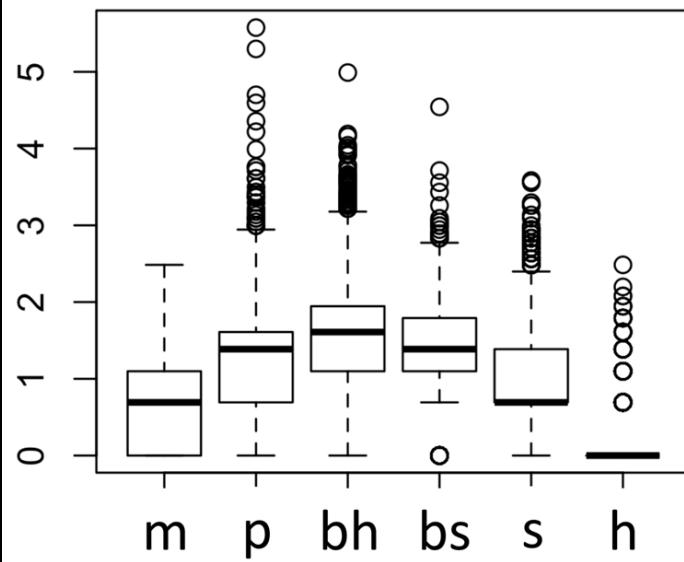
Bibliometric Evidence for a Hierarchy of the Sciences?

parameter	effects of higher consensus:
number of authors	greater scope and need for collaboration
length of article	less need to introduce, justify and explain study
number of references	less need to justify, explain and support study
references to monographs	focus on simpler questions; less need to justify, explain and support study
age of references	faster settling of disagreements; greater potential to build research upon previous findings
diversity of sources	fewer research topics, which are of more general interest
relative title length	clearly defined, substantive research questions
use of first person (singular vs. plural)	universal validity of claims; less scope for argumentation; fewer appeals to opinion and authority

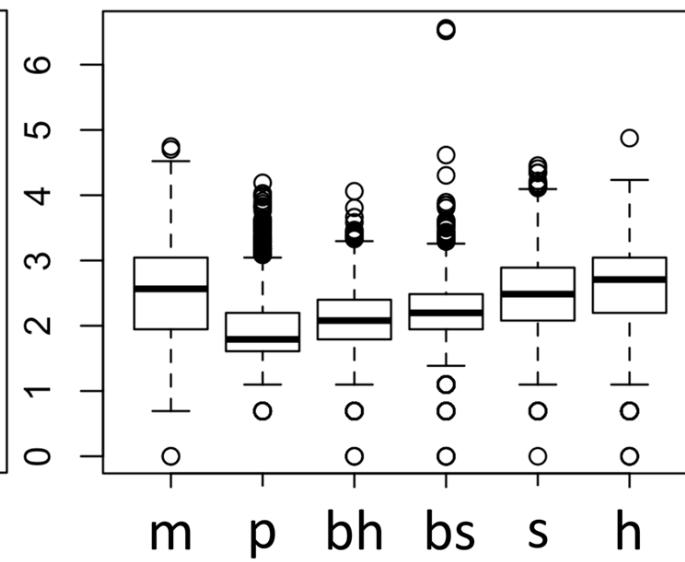
Fanelli D, Gläzel W (2013) Bibliometric Evidence for a Hierarchy of the Sciences. PLOS ONE 8(6): e66938.
<https://doi.org/10.1371/journal.pone.0066938>



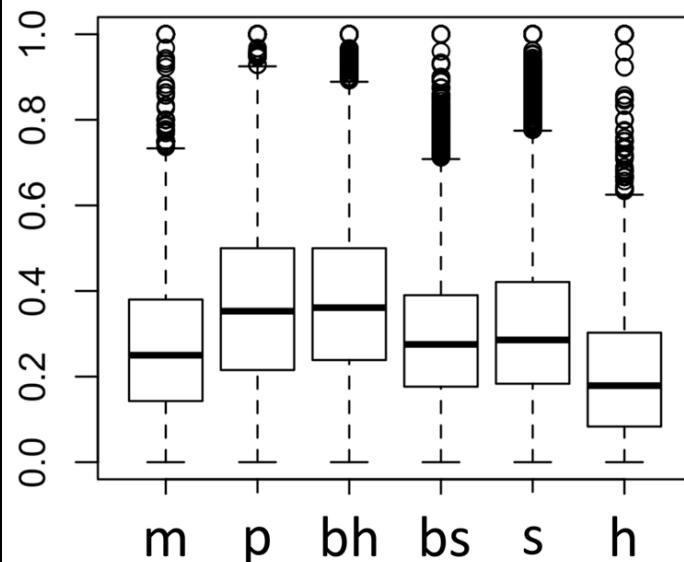
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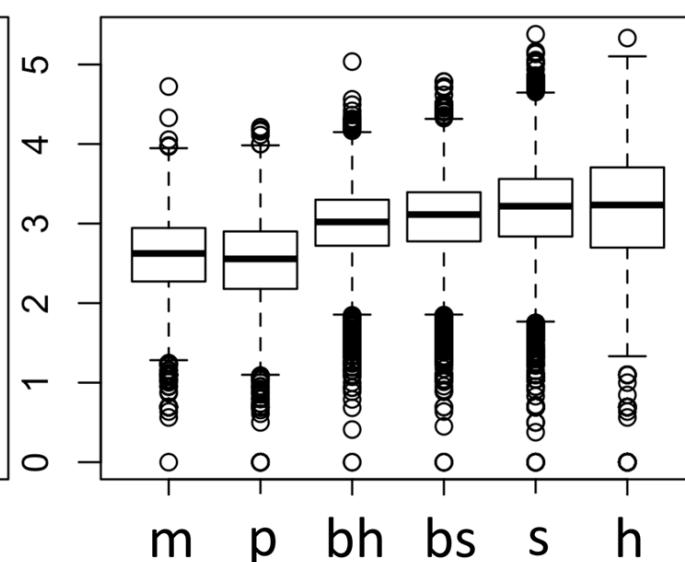
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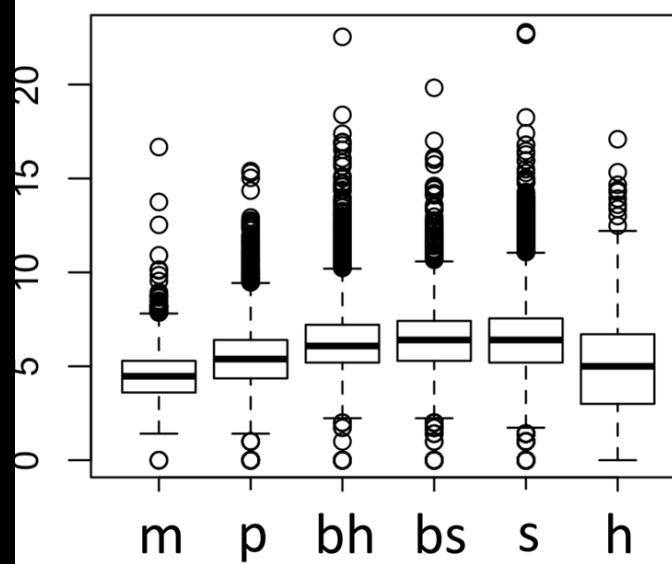


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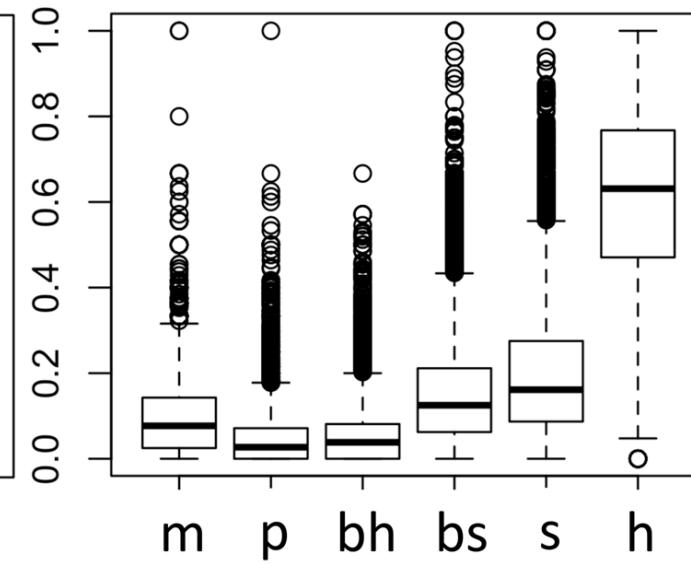




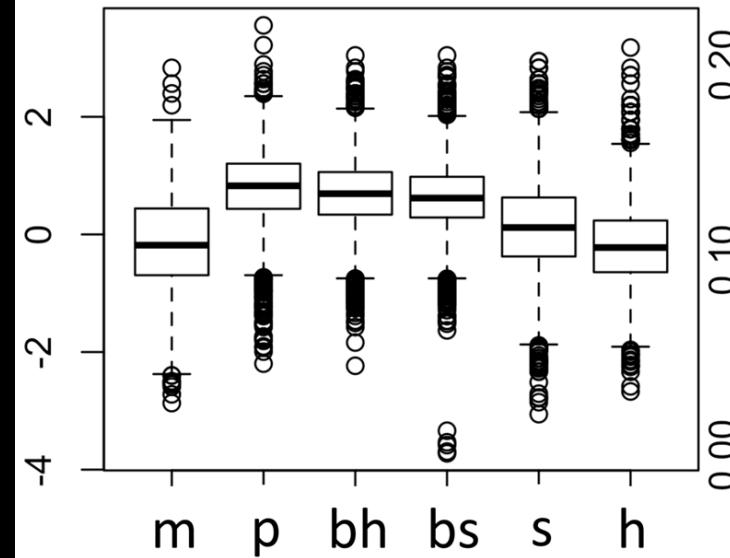
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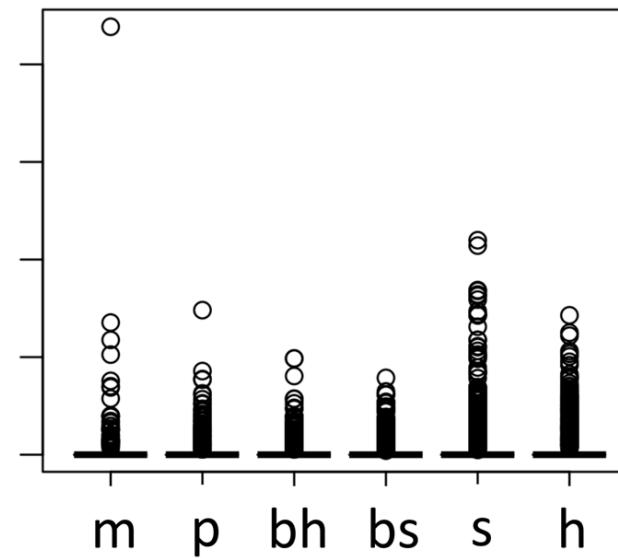
Prop. cited monographs



Relative title length (ln)



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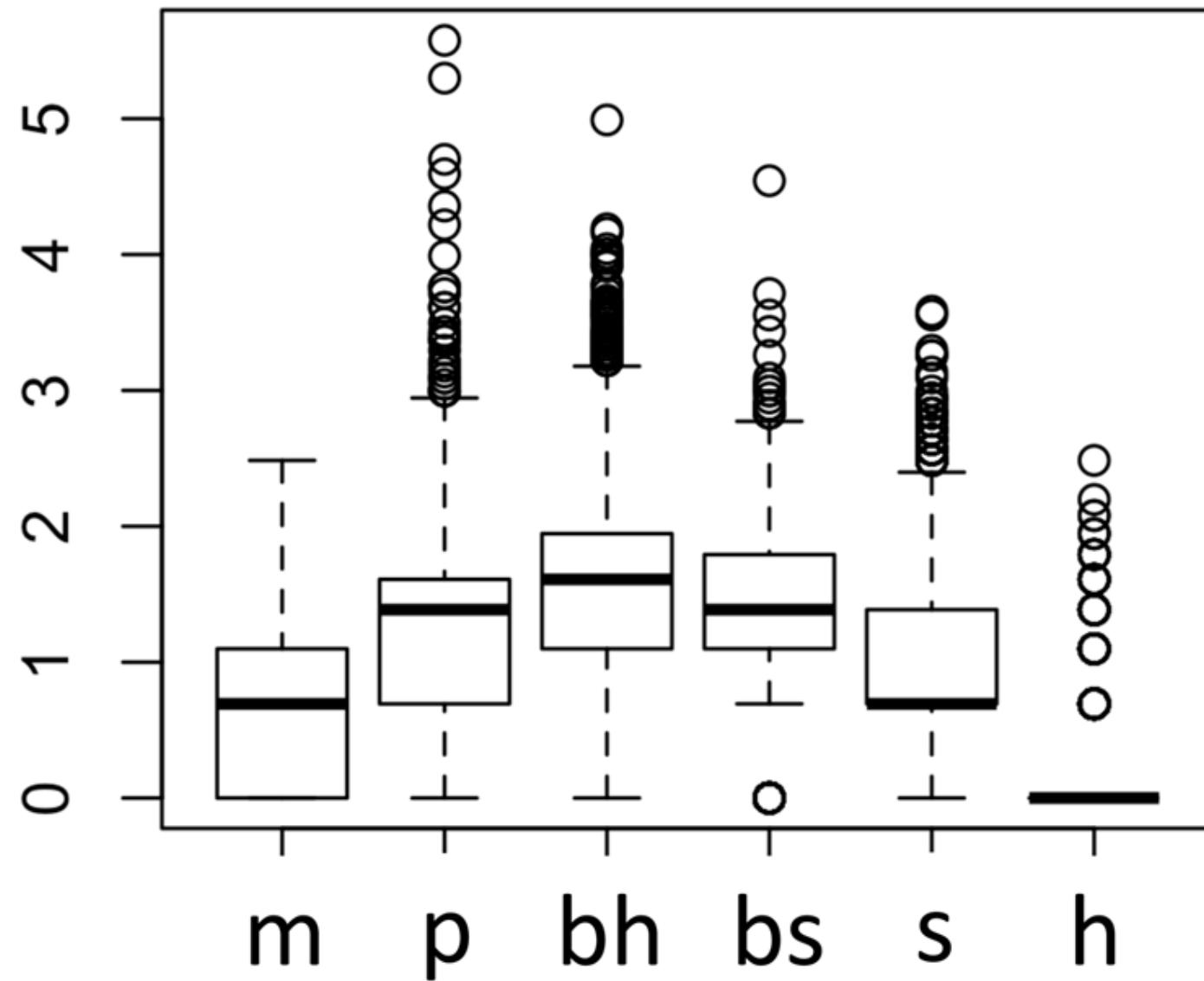


**Where does
archaeology
fit?**

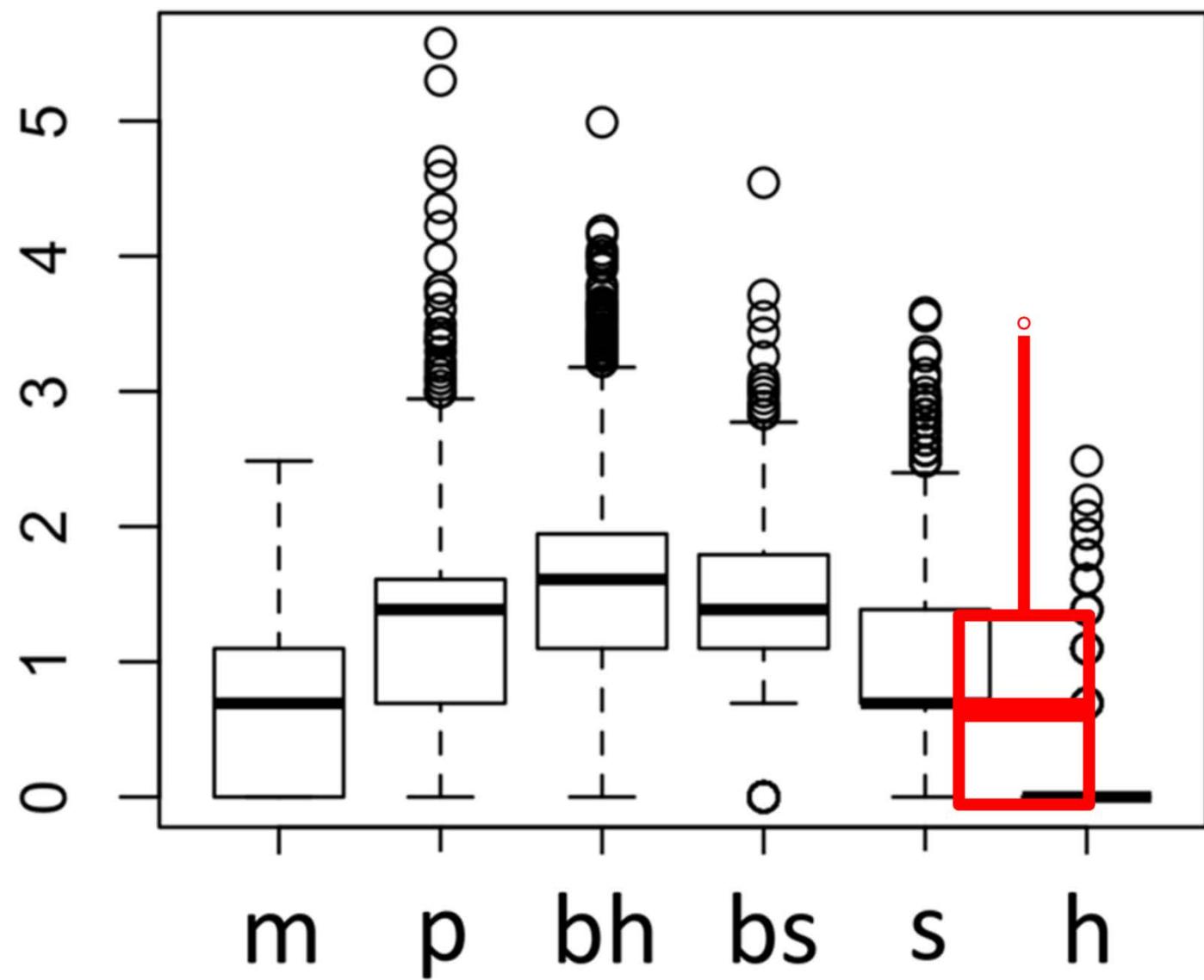
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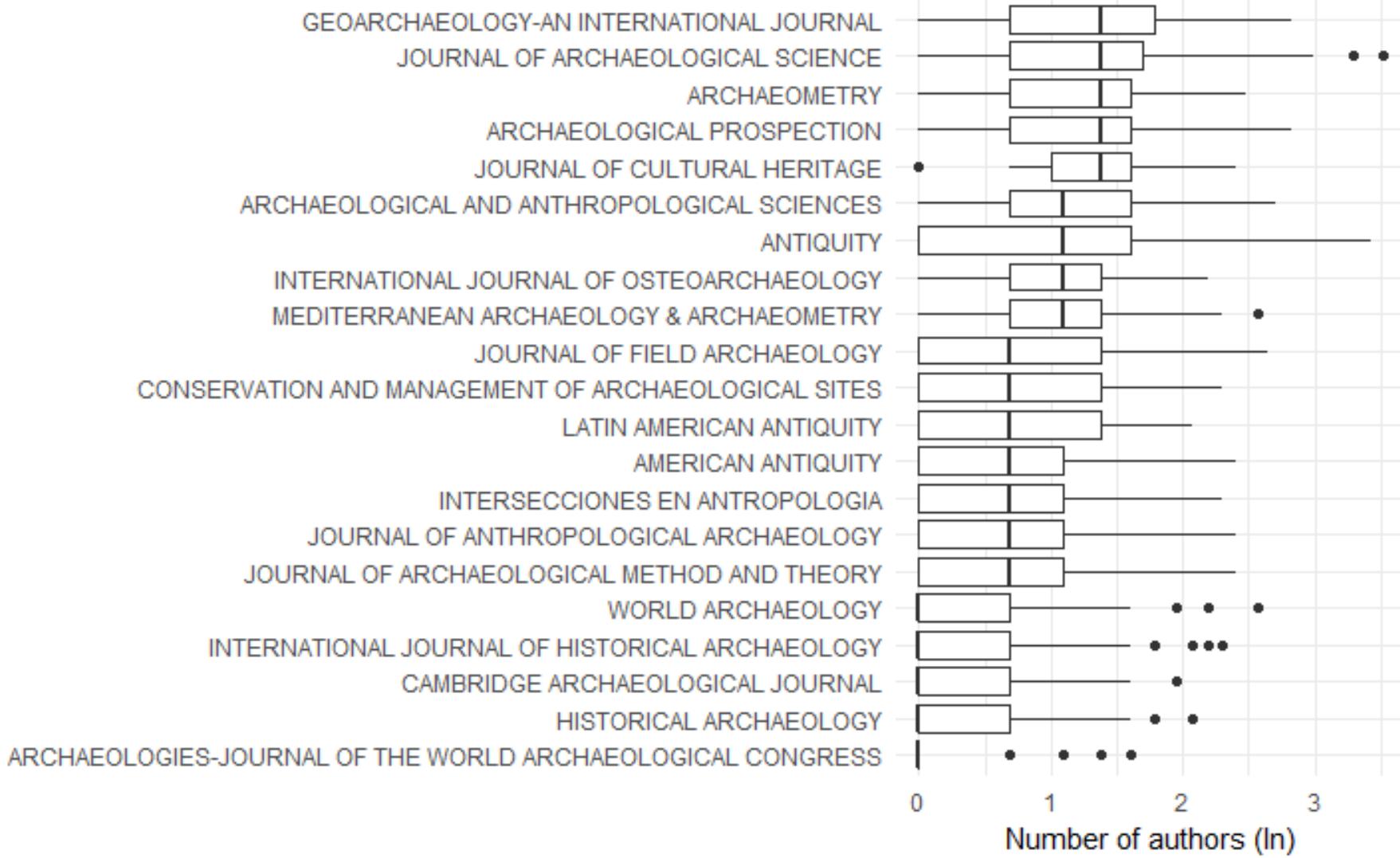


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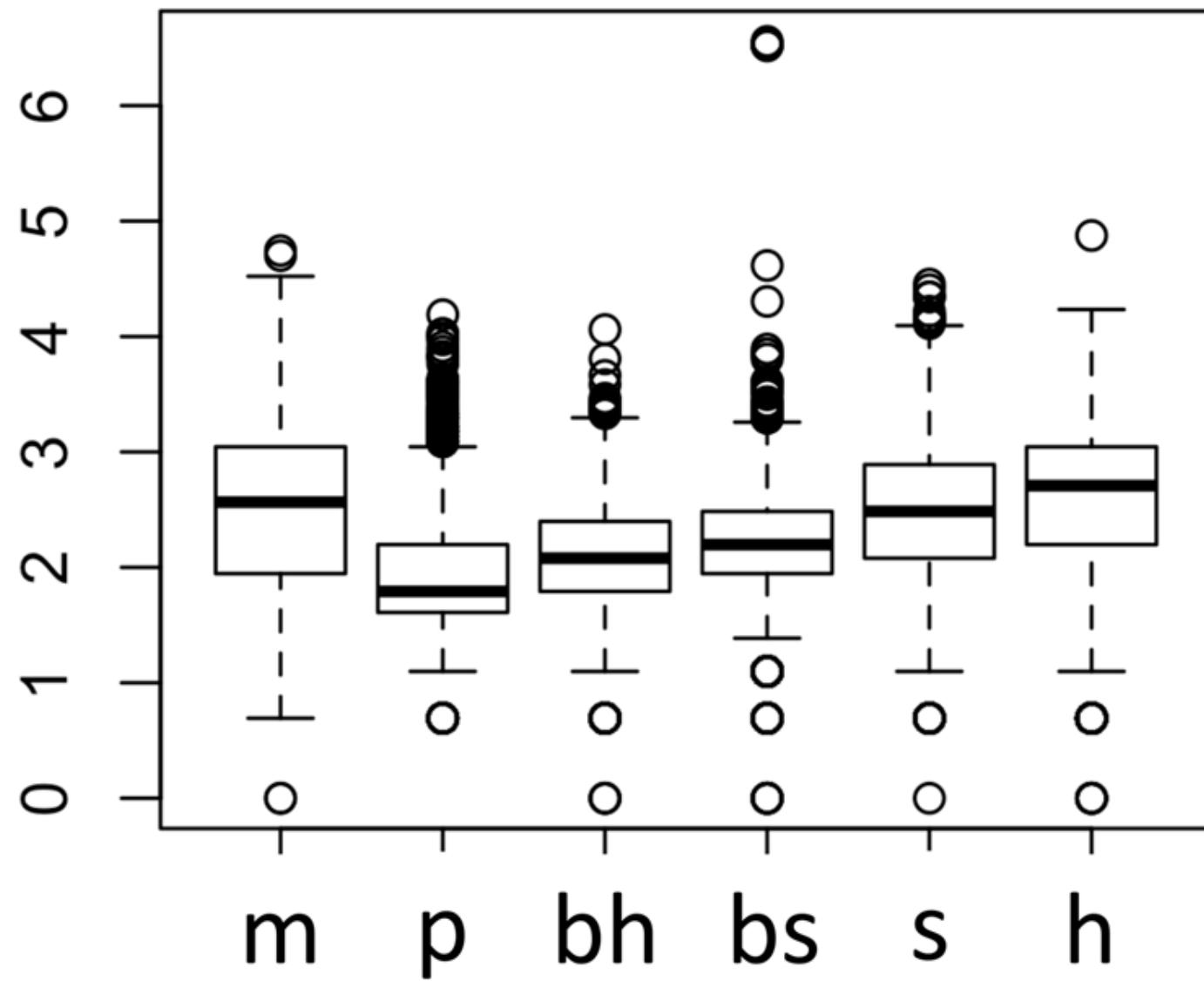


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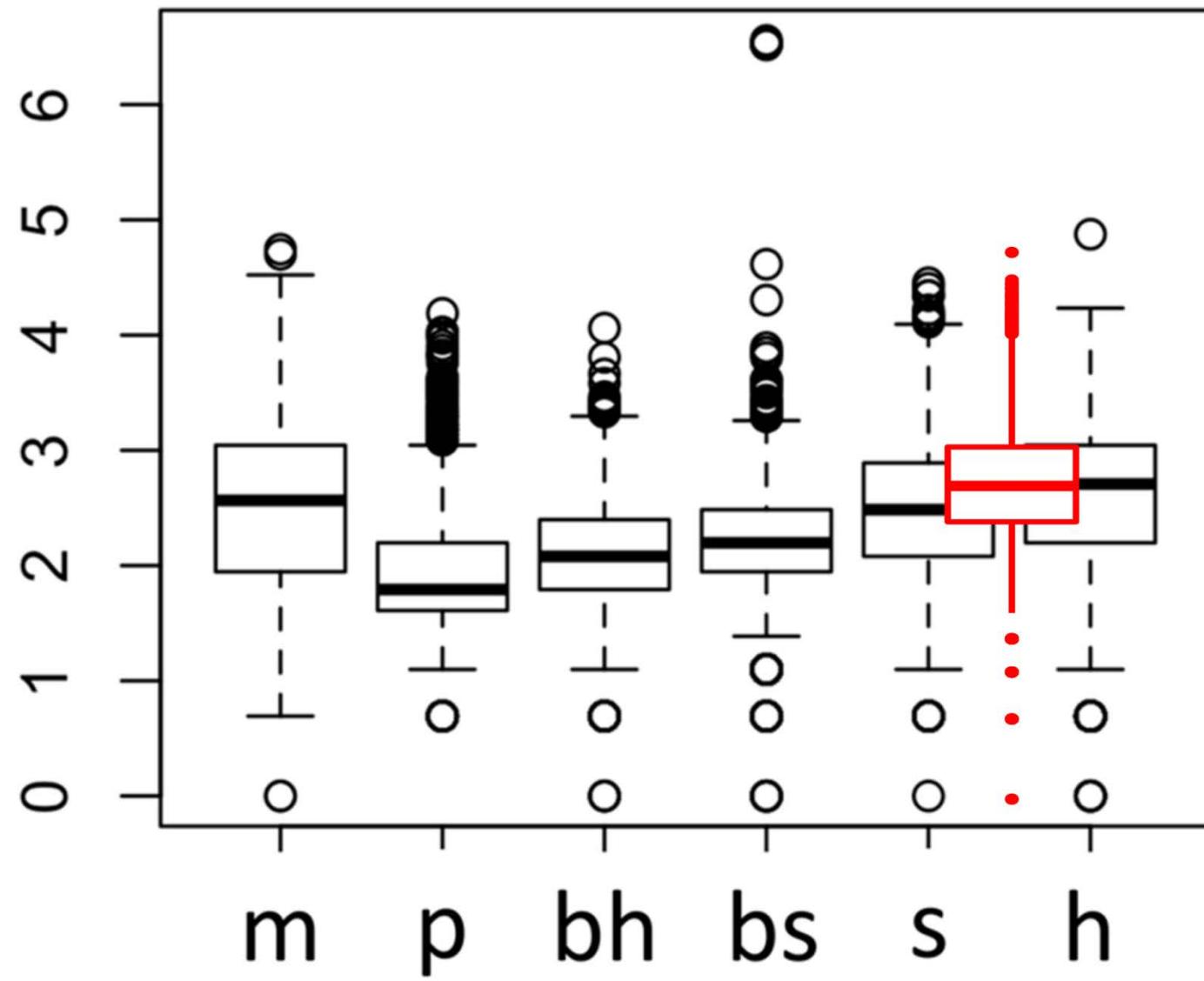




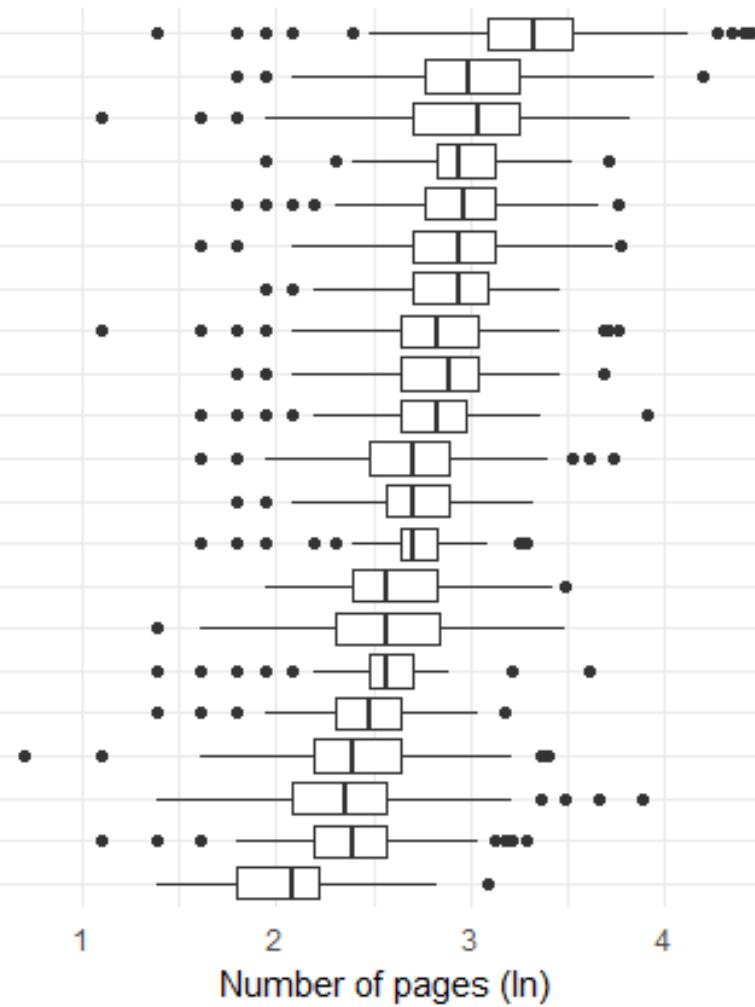
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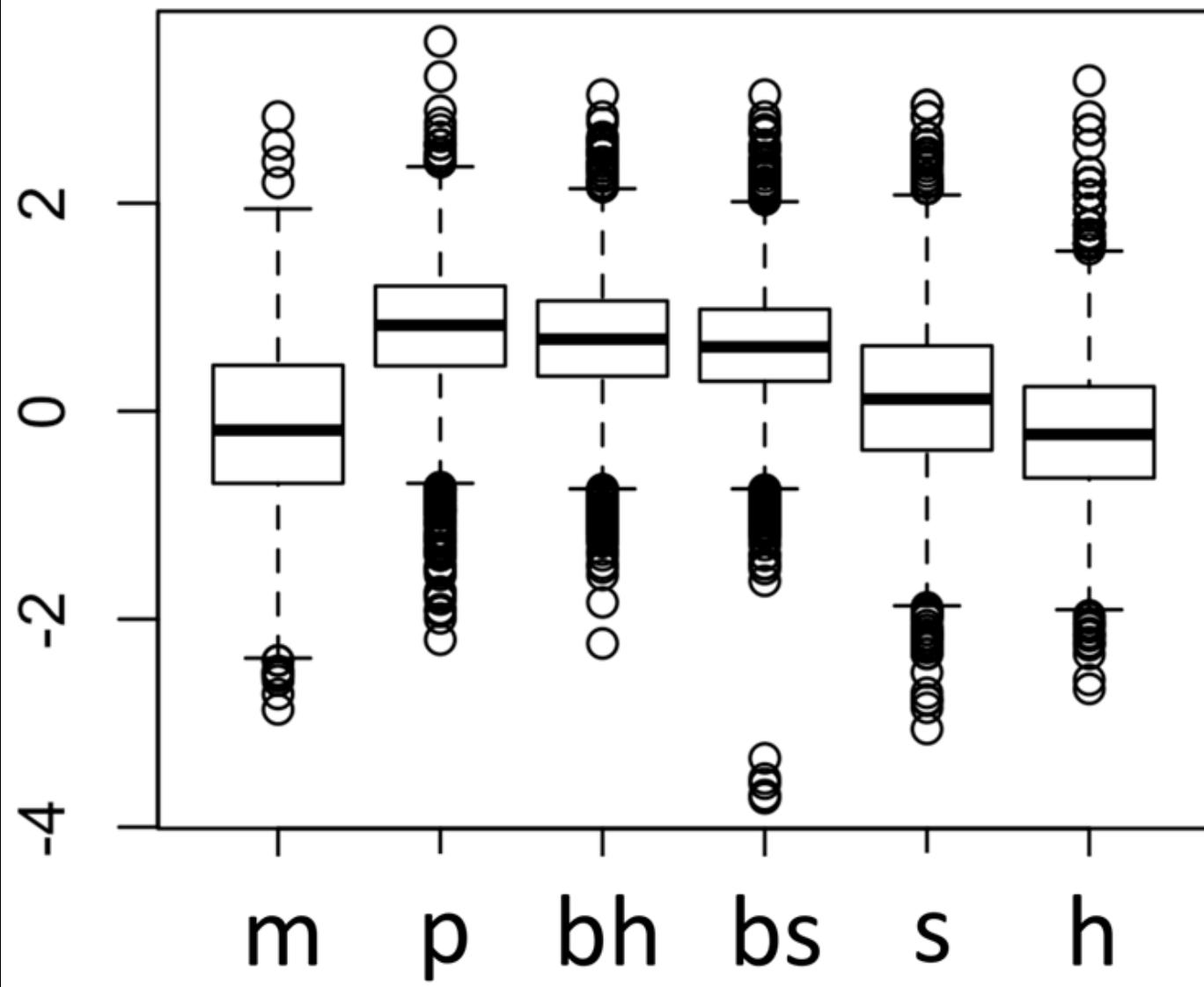
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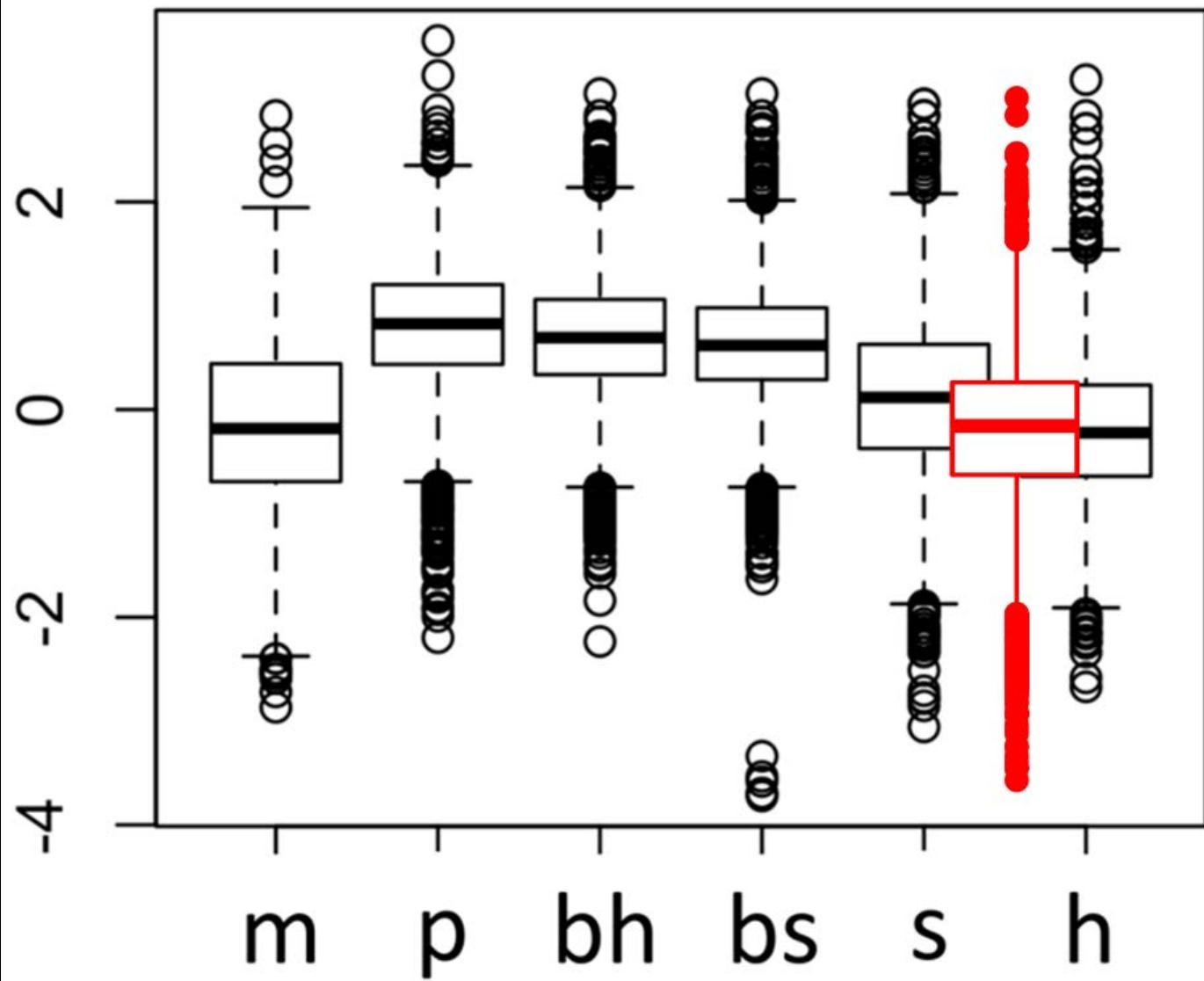
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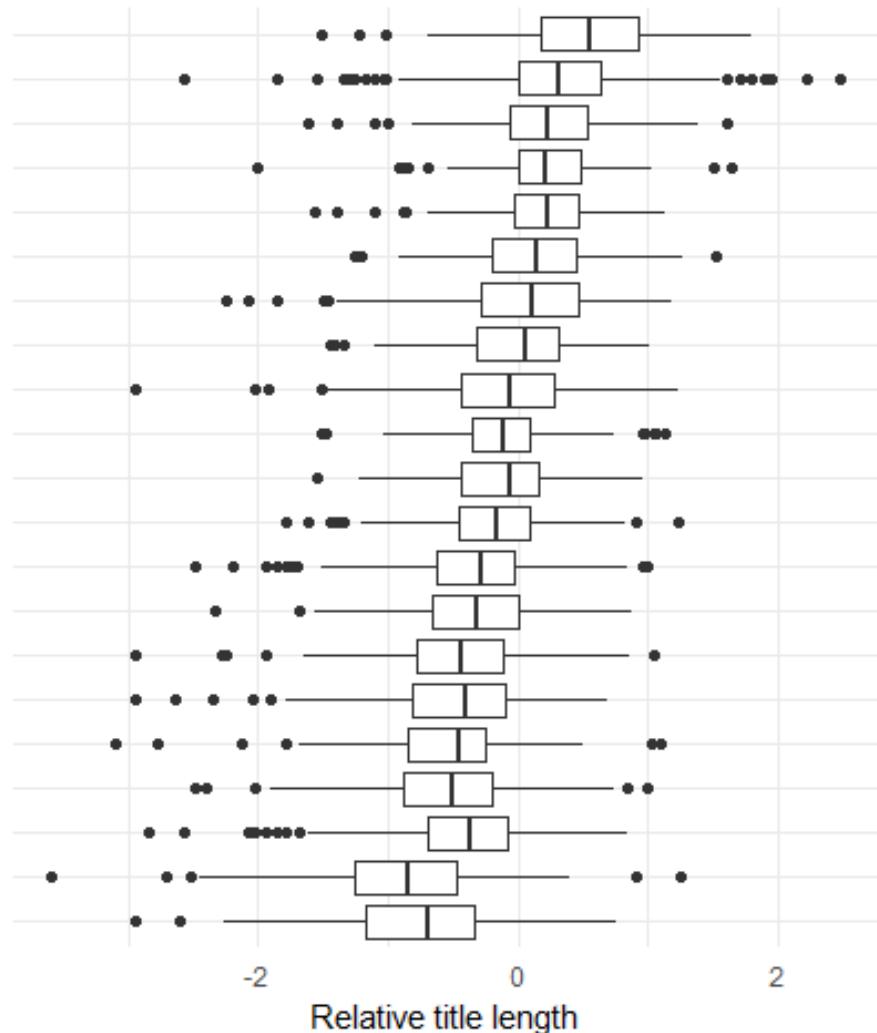
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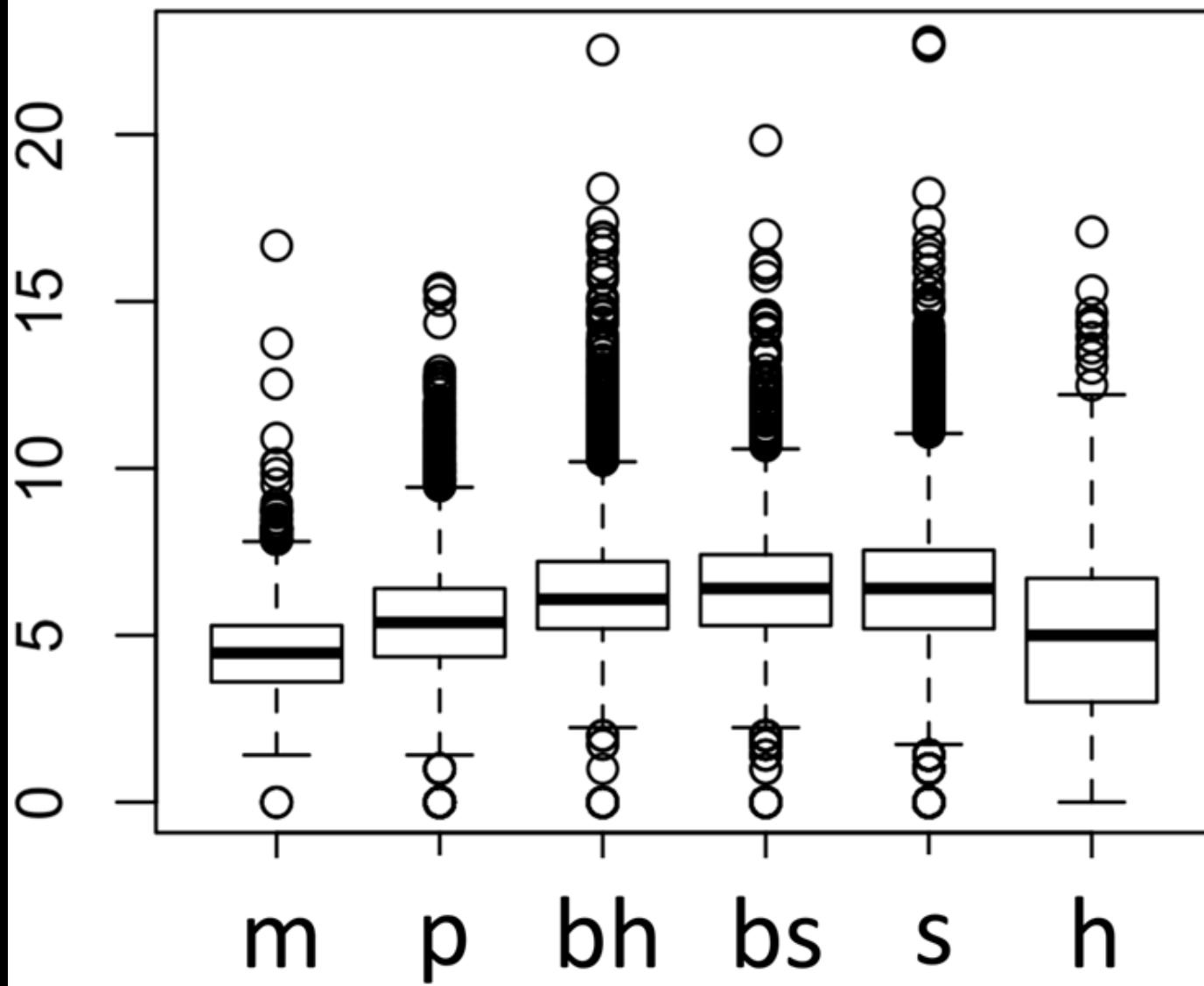
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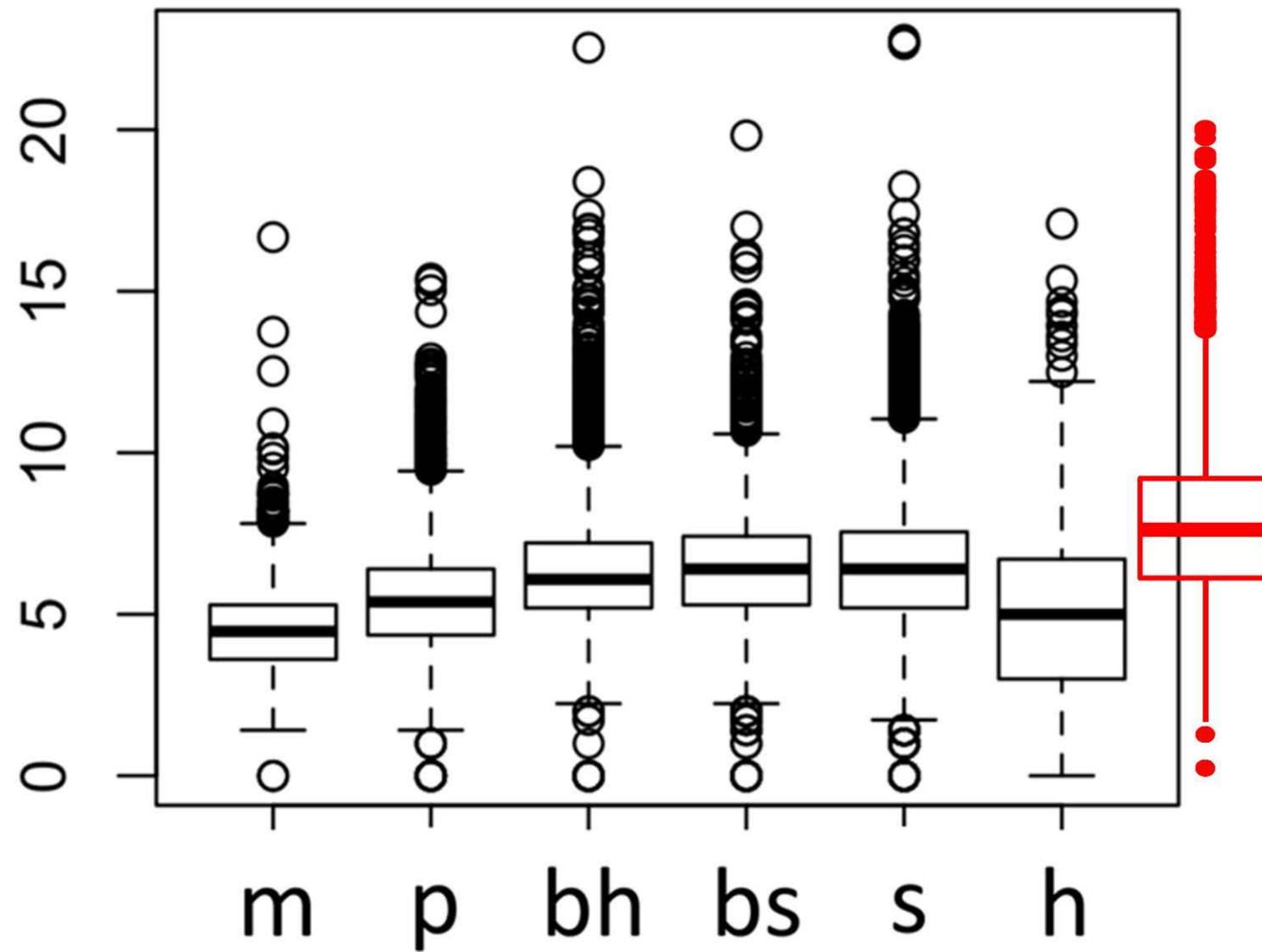
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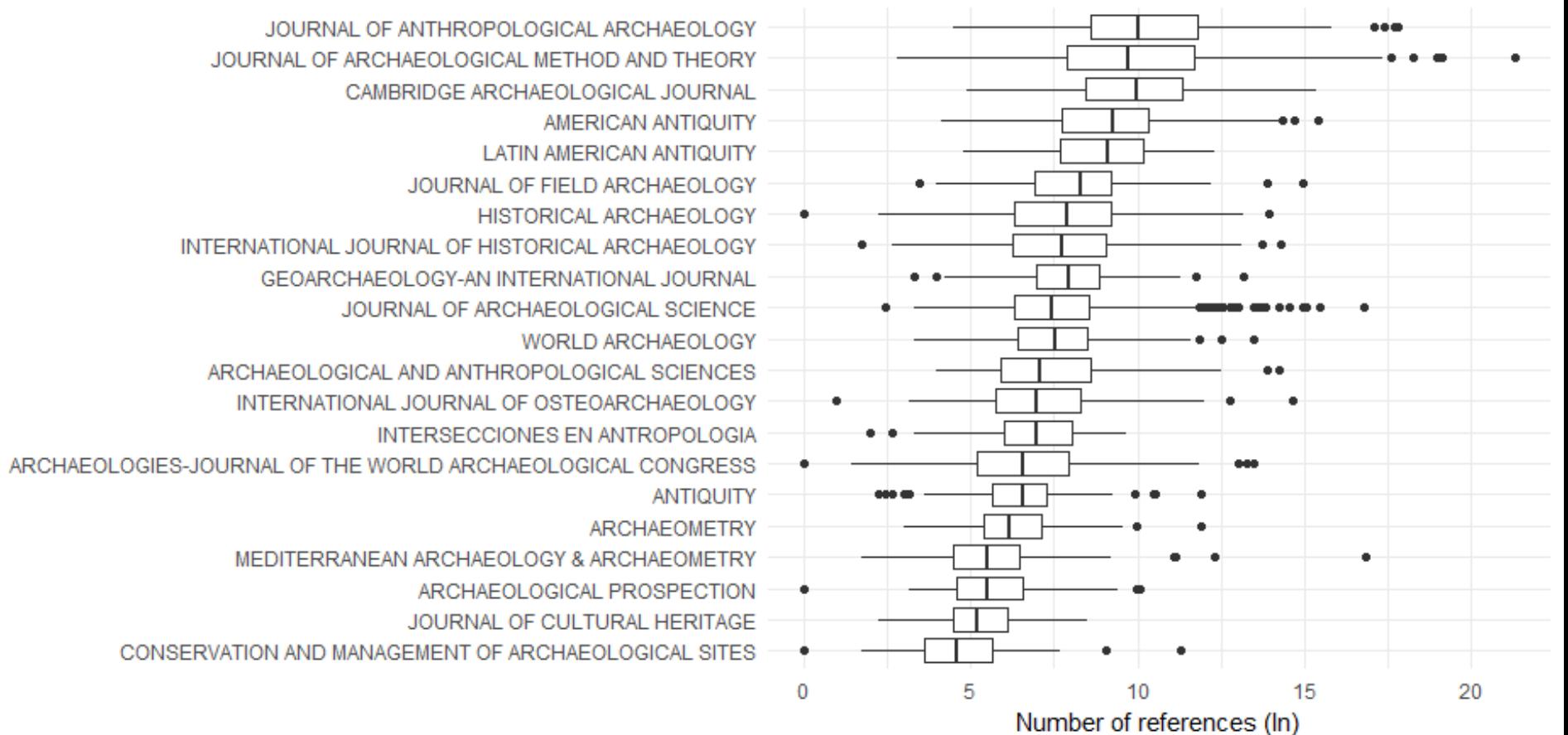


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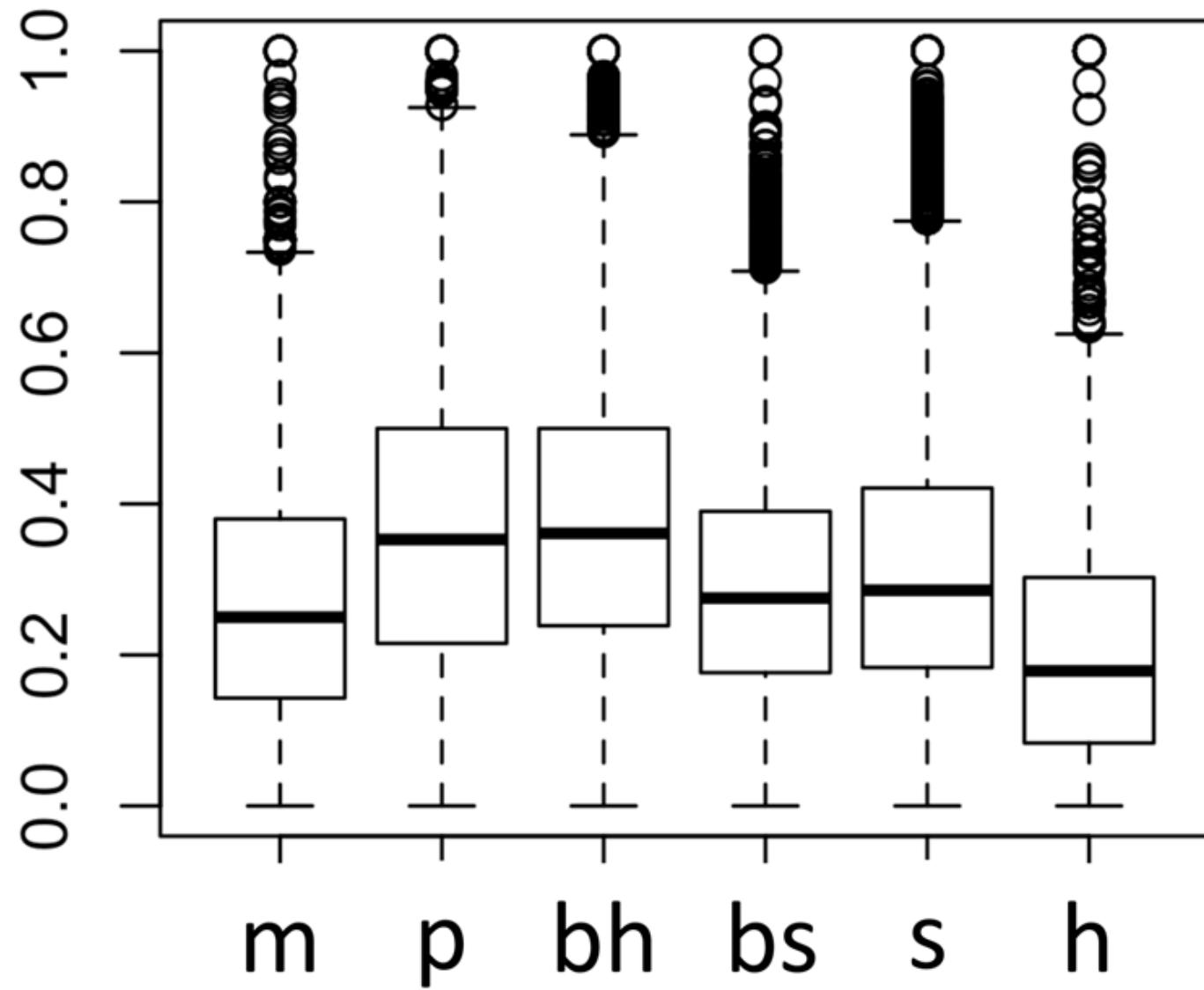


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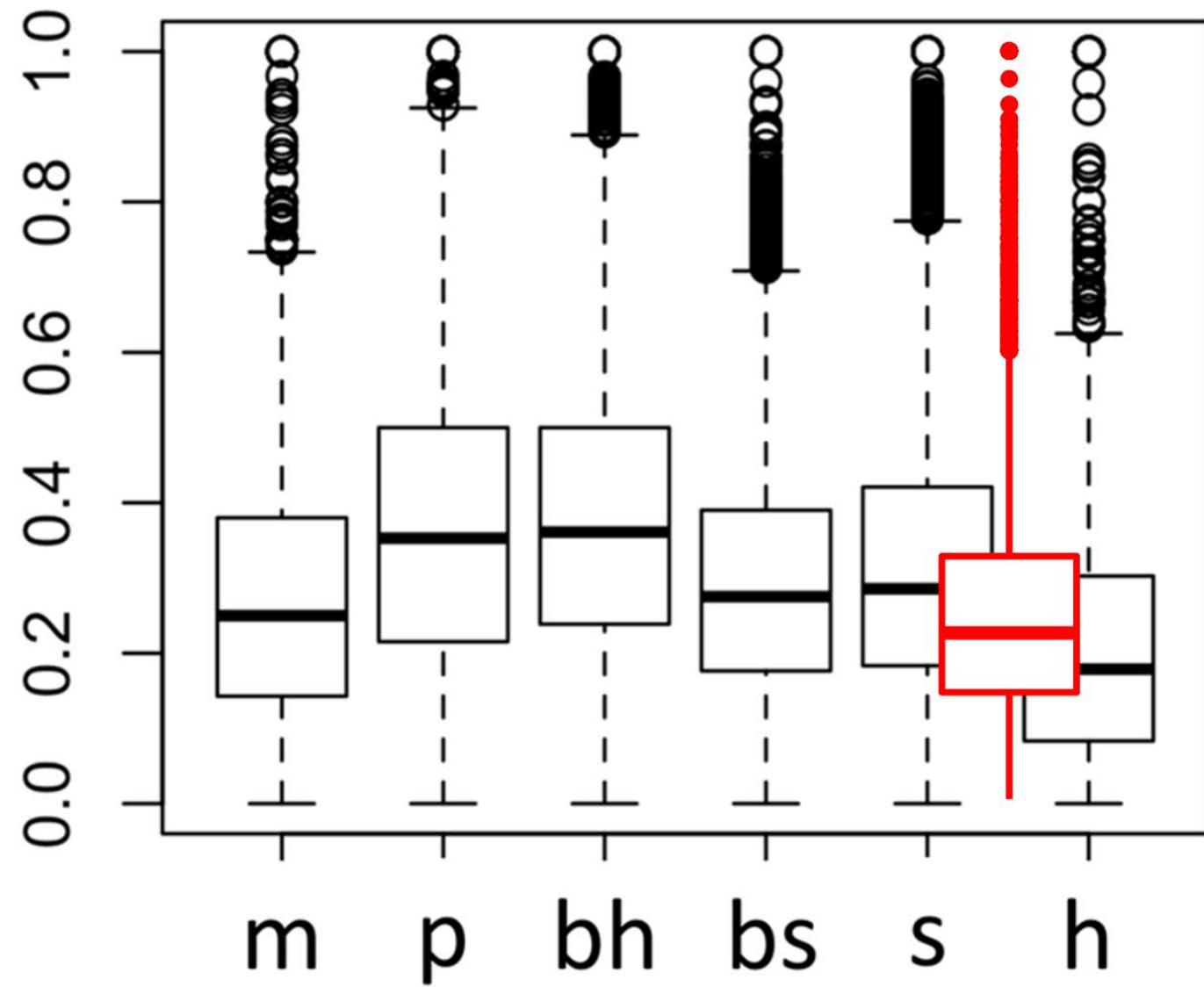


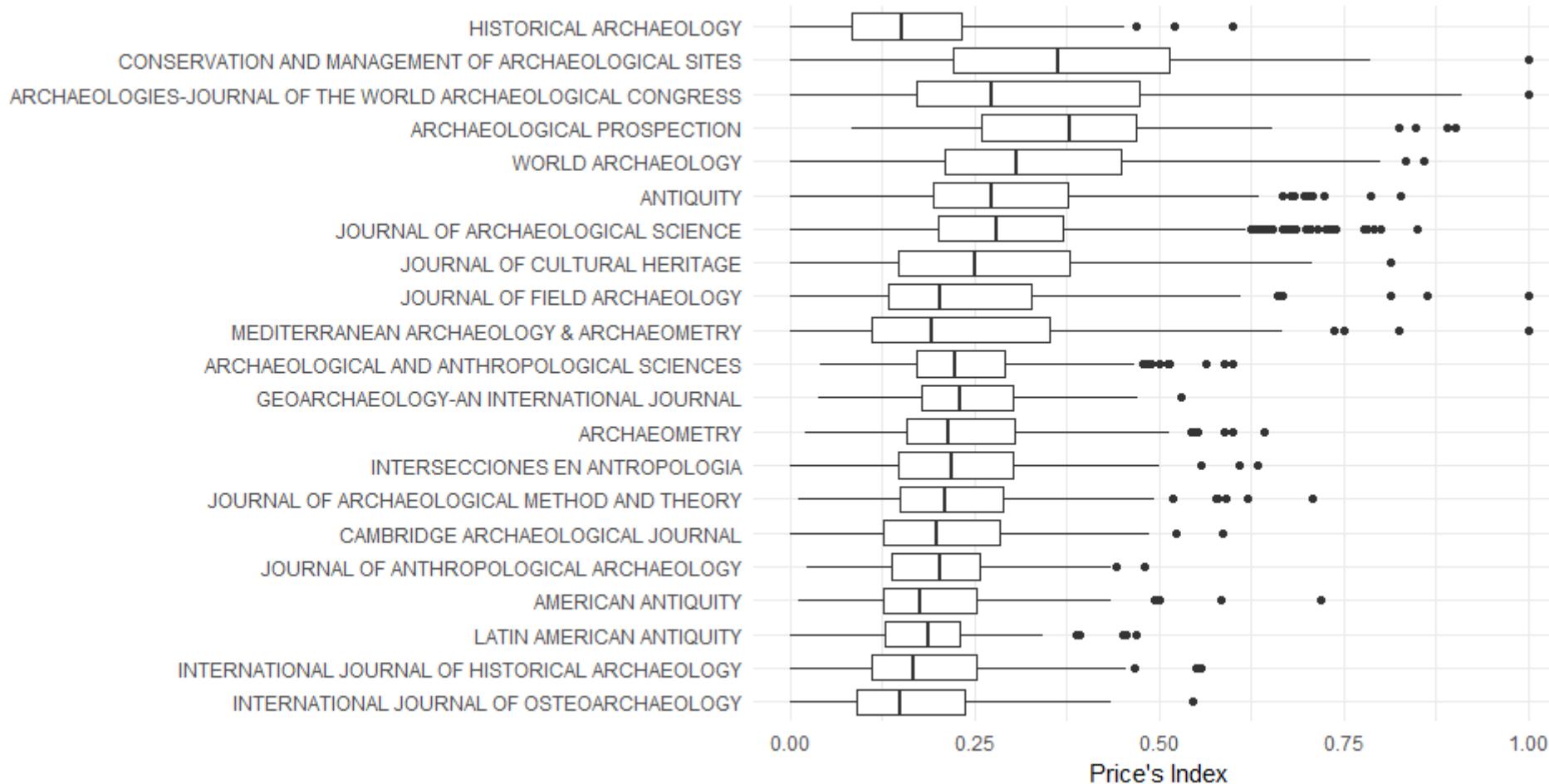


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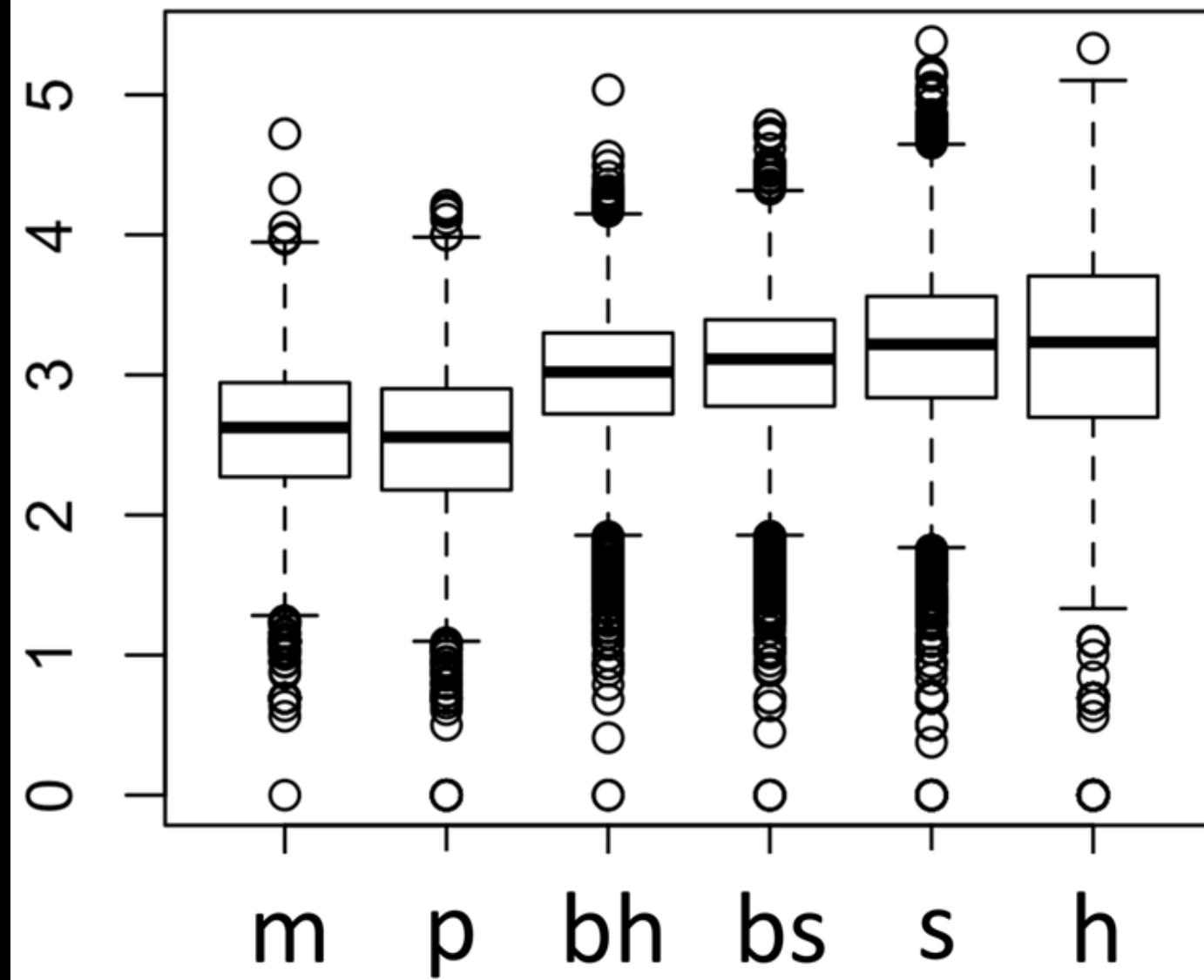


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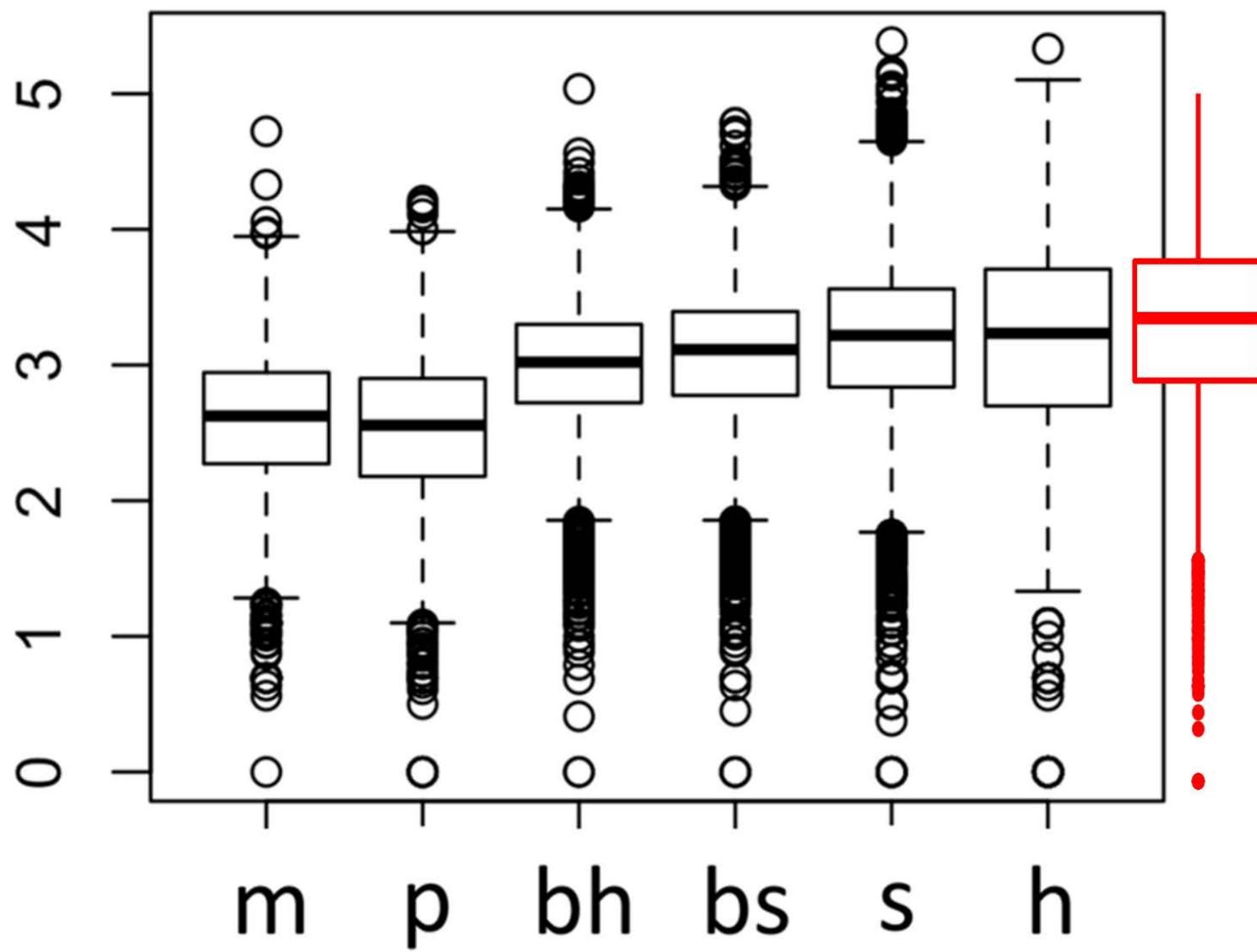




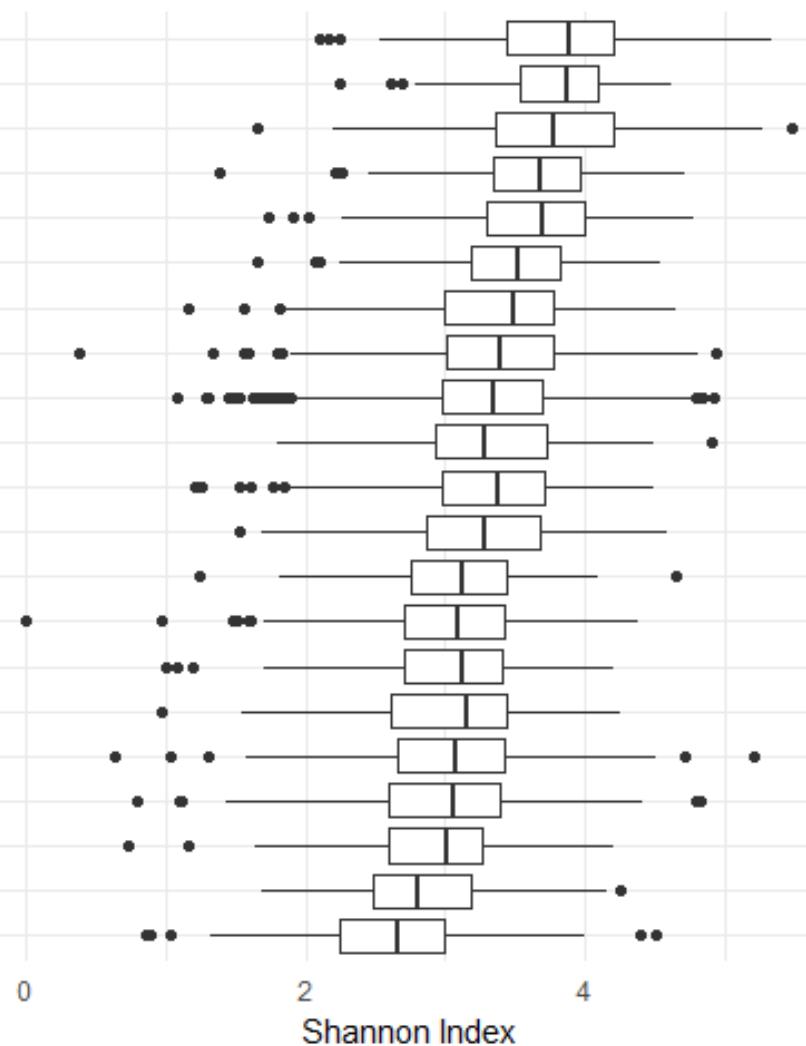
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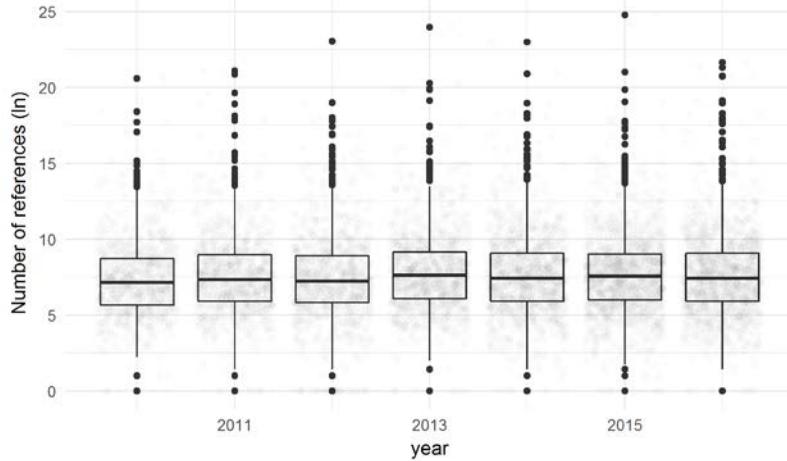
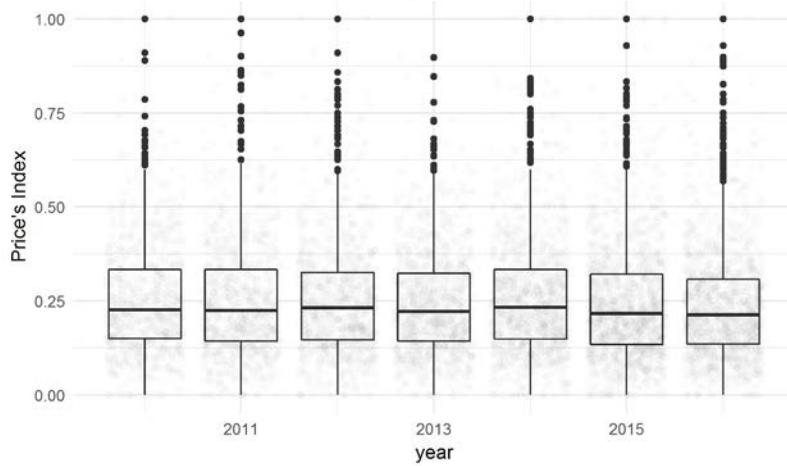
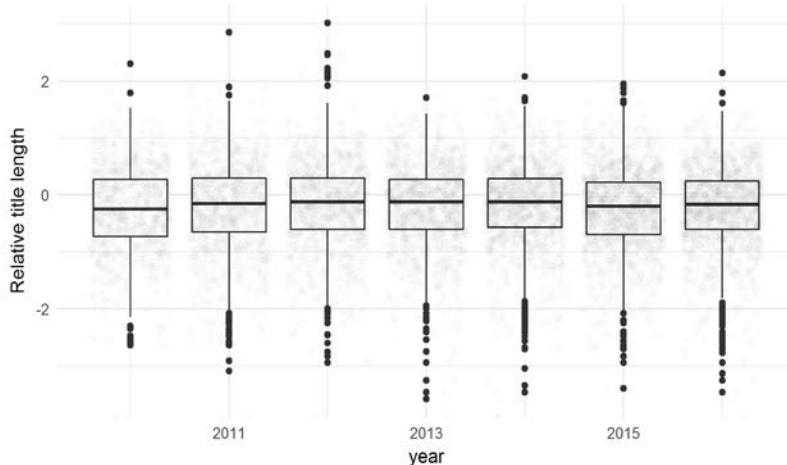
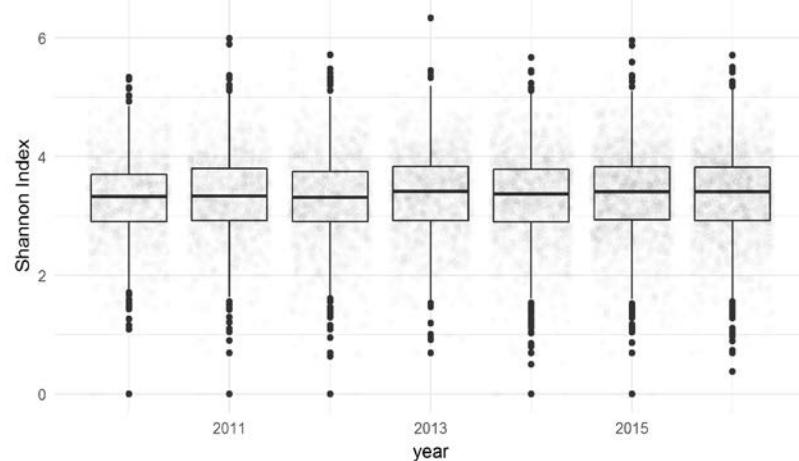
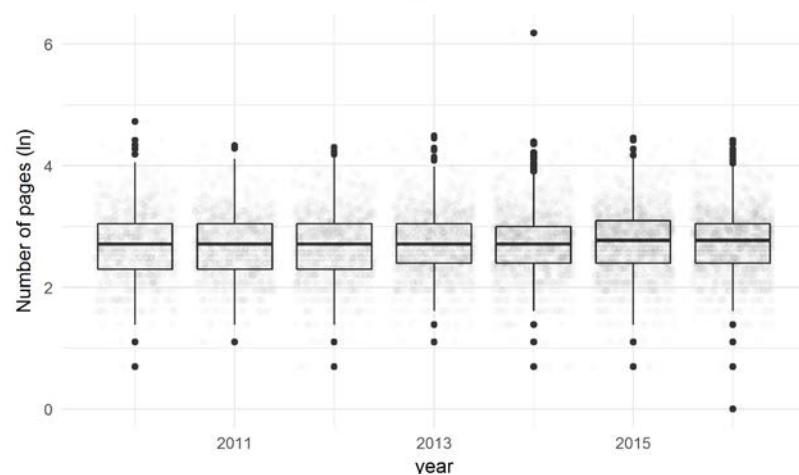
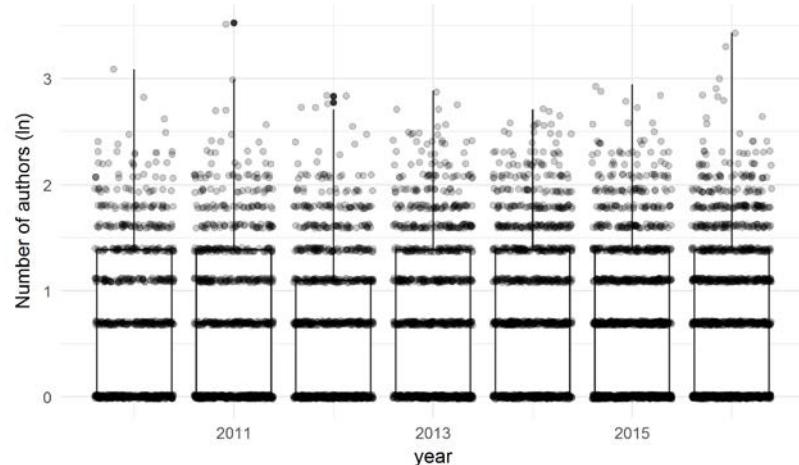


Bibliometric analysis indicates that archaeology is not much like a science.

By most measures it is between social science and humanities

And by some measures, less like a science than the humanities!

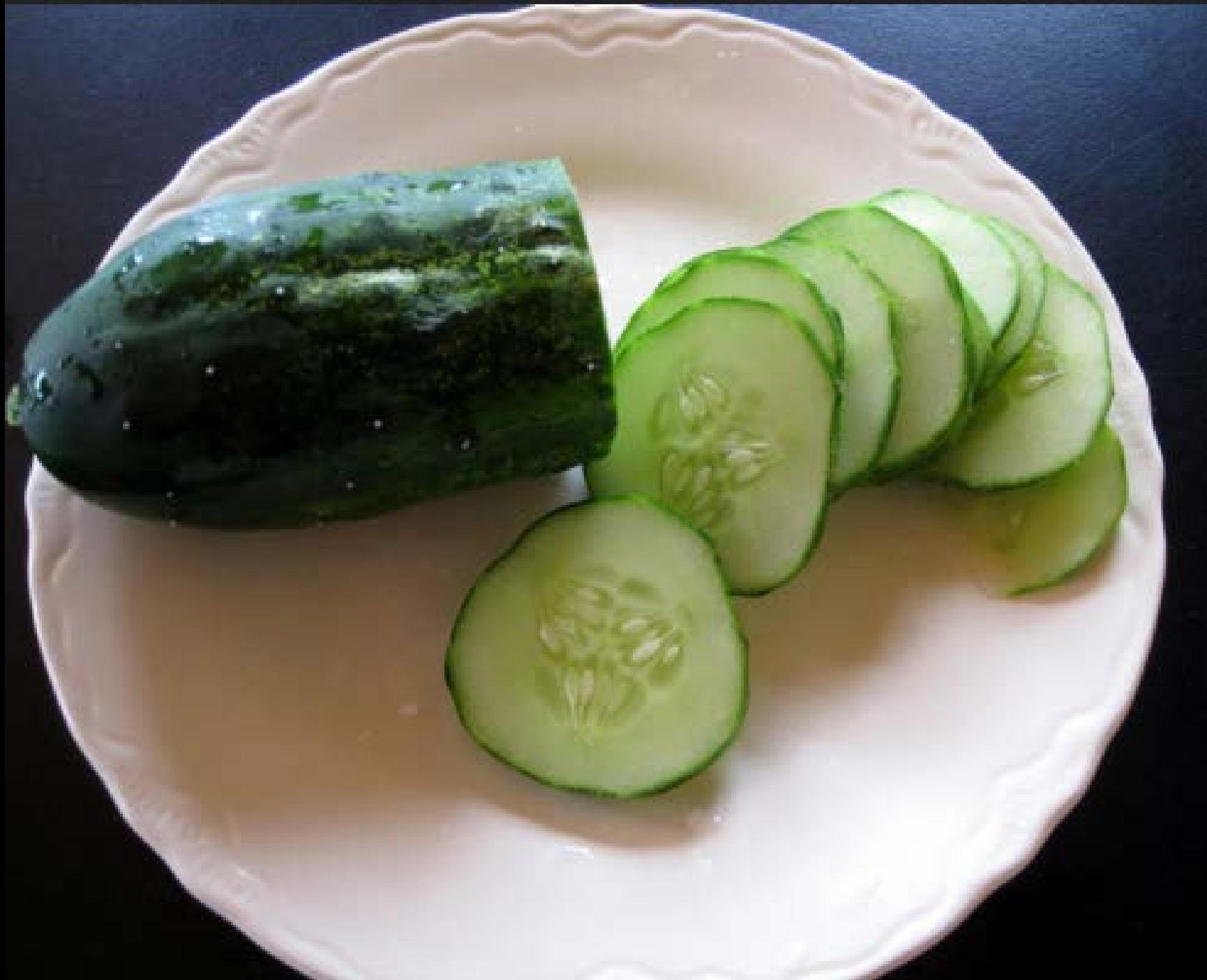
Sidenote: What
about change
over time?



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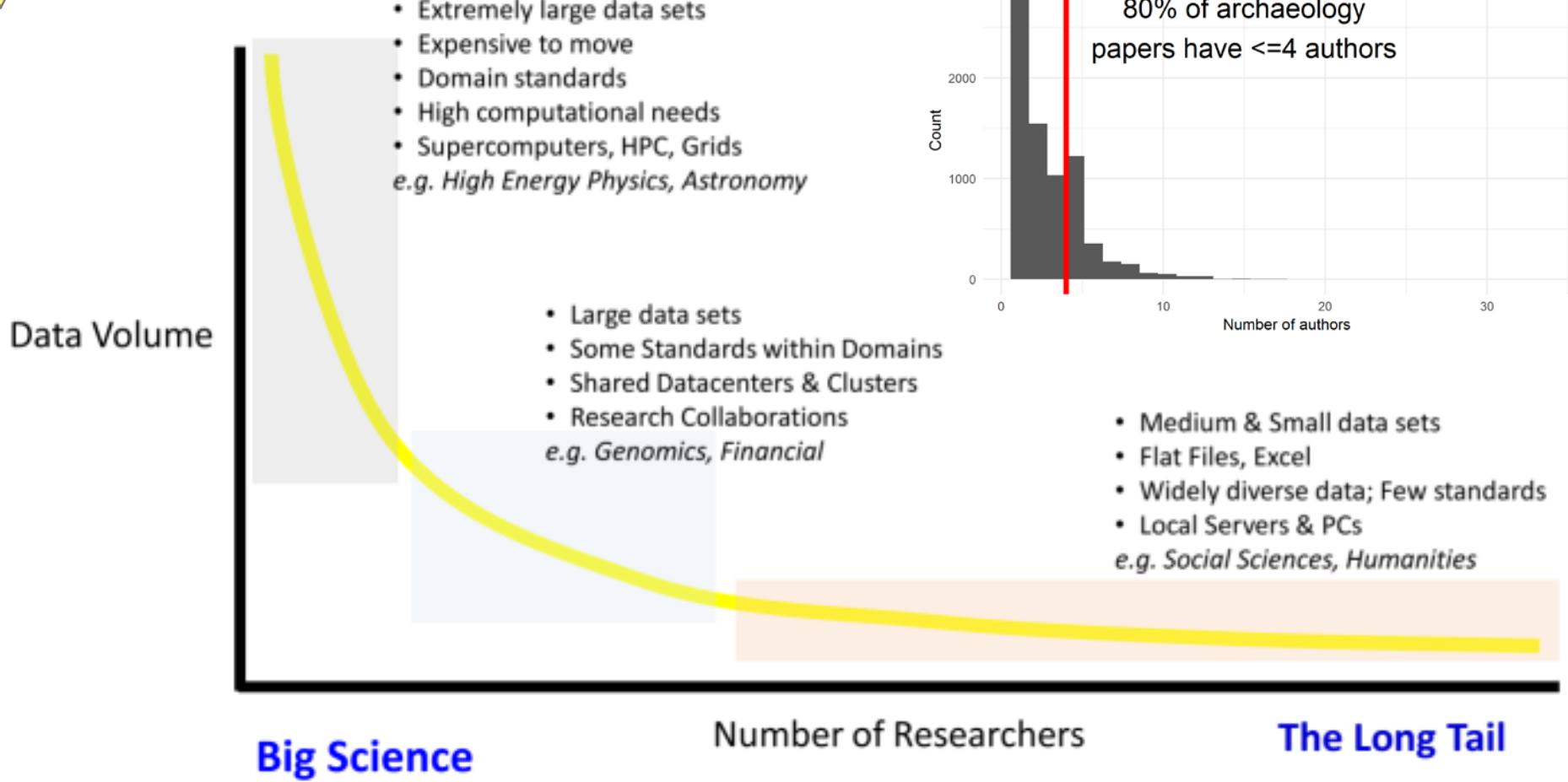


How to
be a
science

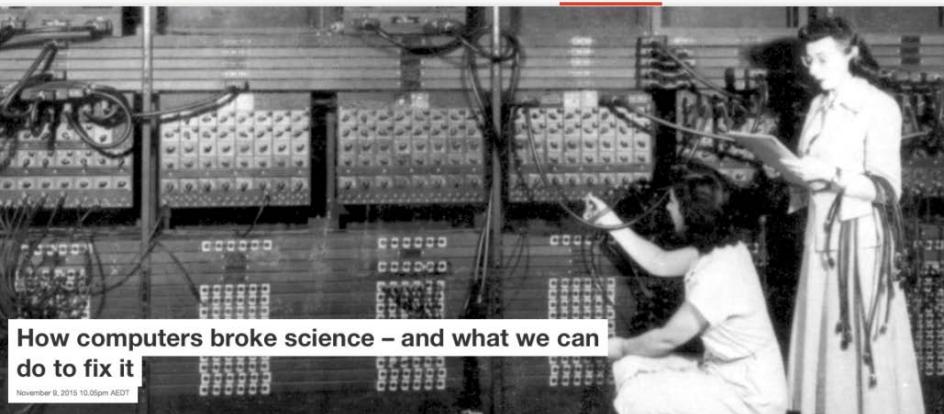


“Getting information
from a table is like
extracting sunlight
from a cucumber”

Farquhar A. & B. Farquhar (1891) *Economic and industrial delusions: A discourse of the case for protection*. New York, Putnam



Bigger sciences have self-organised data sharing norms, standards, services and technologies



How computers broke science – and what we can do to fix it

November 9, 2015 10.05pm AEDT

Computer... or black box for data? US Army

Reproducibility is one of the cornerstones of science. Made popular by British scientist [Robert Boyle](#) in the 1660s, the idea is that a discovery should be reproducible before being accepted as scientific knowledge.

Les ordinateurs nuisent gravement à la science, mais il est possible d'y remédier (1)

December 17, 2015 4.42pm AEDT



Author

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Disclosure statement

Ben Marwick a reçu des financements de l'organisme Australian Research Council. Il est membre associé de l'institut eScience de l'université de Washington (Data Science Fellow). Il est un contributeur des contributions suivantes :

How Computers Broke Science—and What We Can Do to Fix It

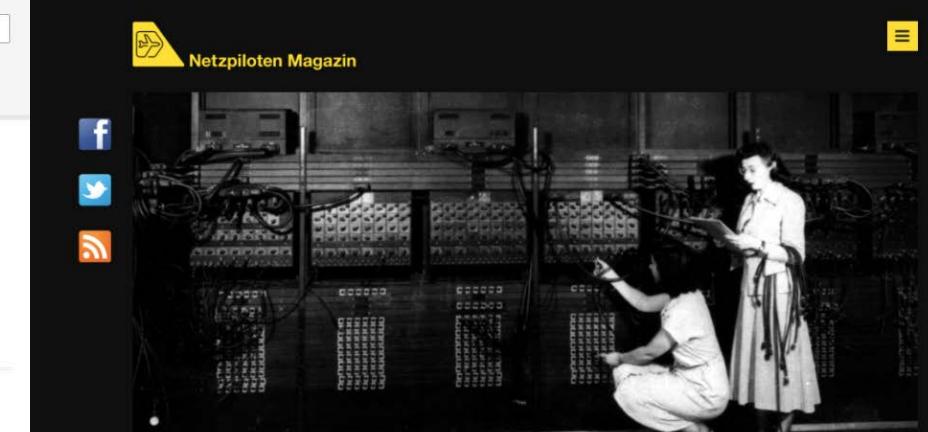
Ben Marwick
1/10/15 3:30am - Filed to: COMPUTERS

14.3K 55 9



Virtually every researcher relies on computers to collect or analyze data. But when computers are opaque black boxes that manipulate data, it's impossible to replicate studies – a core value for science.

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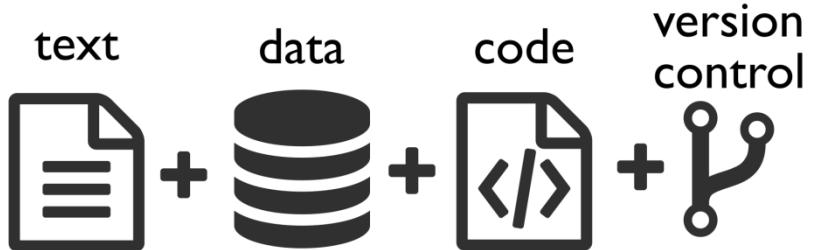


DATA 18. NOV 2015 BEN MARWICK

Wie Computer die Wissenschaft kaputt machen

Die Reproduzierbarkeit ist einer der Grundpfeiler der Wissenschaft. Bekannt geworden ist die Idee durch den britischen Wissenschaftler [Robert Boyle](#) um 1660. Grundsätzlich geht es darum, dass eine Entdeckung reproduzierbar sein muss, um wissenschaftlich anerkannt zu werden. Im Grunde sollte gelten, dass jeder die gleichen Ergebnisse erhält, wenn man die vorgeschriebene Methode exakt folgt. Beispielsweise, wenn Forscher die Effektivität einer neuen medizinischen Droge reproduzieren können, dann ist das ein gutes Zeichen, dass dies für alle potenziellen Patienten

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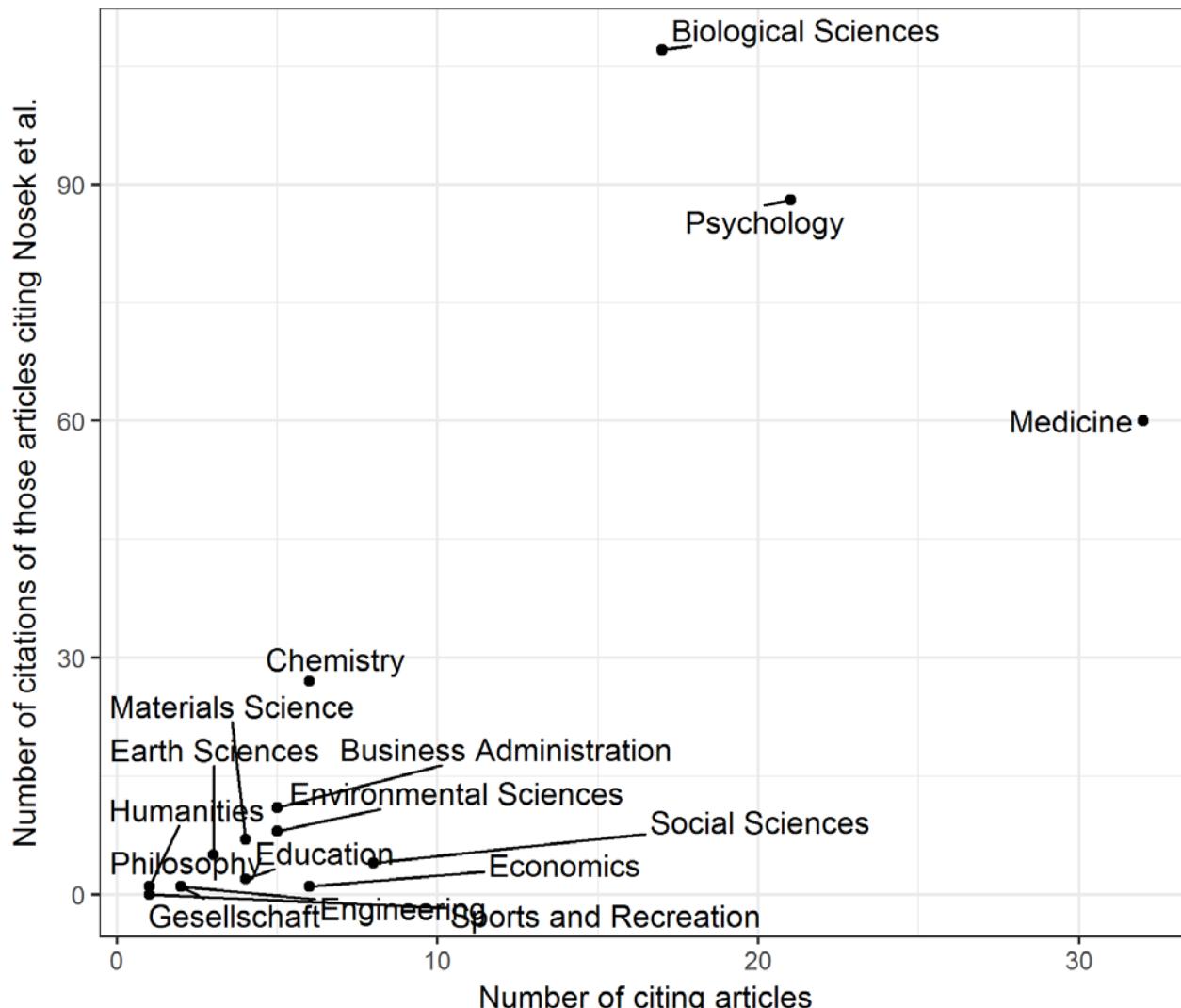
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See also: Marwick, B. (2016). Computational Reproducibility in Archaeological Research: Basic Principles and a Case Study of Their Implementation. Journal of Archaeological Method and Theory 23(2): 1-27.
<http://doi.org/10.1007/s10816-015-9272-9>. This figure is CC-BY



Work with Carole Lee on change in scientific cultures

Disciplines of 141 articles citing

Nosek B.A., et al. (2015) Promoting an open research culture.
Science, 348 (6242): 1422-1425.



Data from Scopus.

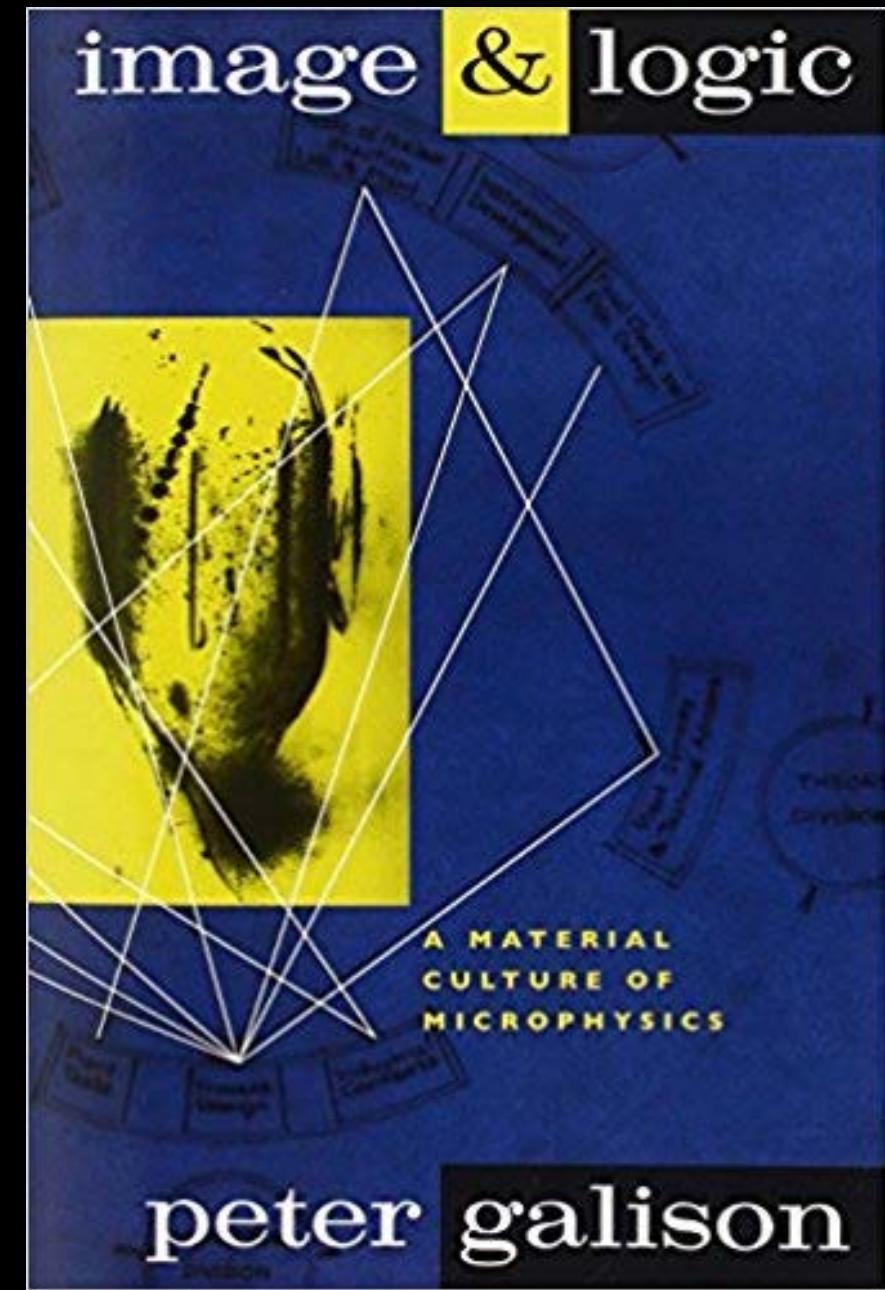


Hello

So, how
can
archaeology
do it?



Yes, I would
like to science
please



A tool-driven change will help archaeology become more like a science



```
## R Markdown
```

This is an [R Markdown](<http://rmarkdown.rstudio.com/>) document. Markdown is a simple formatting syntax for authoring HTML, PDF, and **MS Word** documents.

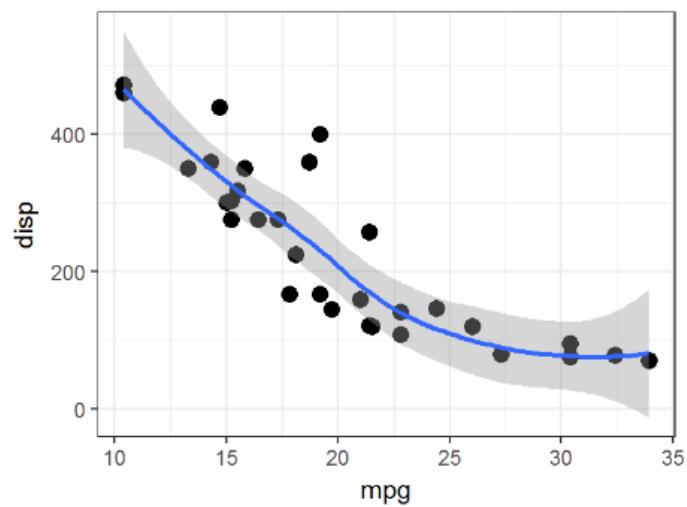
You can use R code in-line with the text. For example, there are `r nrow(cars)` samples in these data. You can also embed a longer chunk of R code to produce a plot like this:

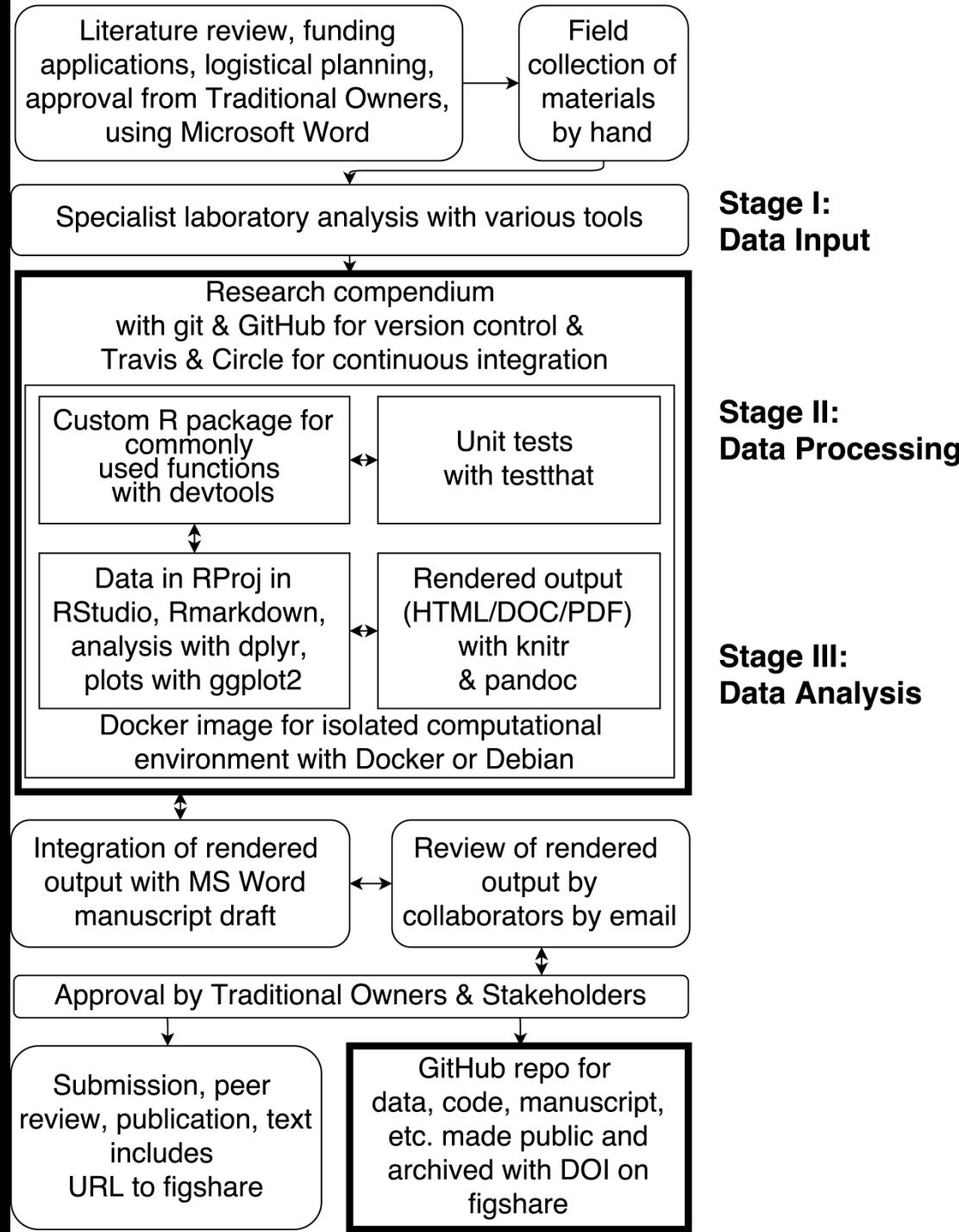
```
```{r cars, echo=FALSE}
library(ggplot2)
ggplot(mtcars,
 aes(mpg,
 disp)) +
 geom_point(size = 3) +
 geom_smooth() +
 theme_bw()
```
```

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and **MS Word** documents.

You can use R code in-line with the text. For example, there are 50 samples in these data. You can also embed a longer chunk of R code to produce a plot like this:





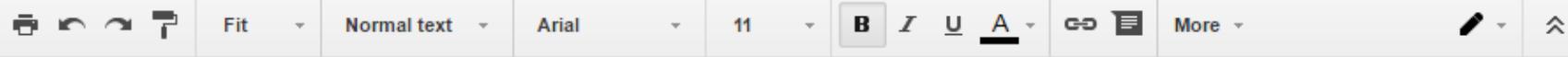
**Is this
sustainable?**

modeled after McCune et al. (2002).

3.4. Reproducibility and open source materials

To enable re-use of our materials and improve reproducibility and transparency according to the principles outlined in Marwick (2016), we include the entire R code used for all the analysis and visualizations contained in this paper in our supplemental online material (SOM) at <https://dx.doi.org/10.6084/m9.figshare.2065602.v1>. Also in this version-controlled compendium are the raw data for all the tests reported here, as well as a custom R package (Wickham, 2015) containing the code written for this paper. All of the figures, tables and statistical test results presented here can be independently reproduced with the code and data in this repository. In our SOM our code is released under the MIT licence, our data as CC-0, and our figures as CC-BY, to enable maximum re-use (for more details about these licences, see Marwick, 2016).

4. Results



Open Science in Archaeology

Ben Marwick*, Jade d'Alpoim Guedes, C. Michael Barton, Lynsey A. Bates, Michael Baxter, Andrew Bevan, Elizabeth A. Bollwerk, R. Kyle Bocinsky, Tom Brughmans, Alison K. Carter, Cyler Conrad, Daniel A. Contreras, Stefano Costa, Enrico R. Crema, Adrienne Daggett, Benjamin Davies, B. Lee Drake, Thomas S. Dye, Phoebe France, Richard Fullagar, Domenico Giusti, Shawn Graham, Matthew D. Harris, John Hawks, Sebastian Heath, Damien Huffer, Eric C. Kansa, Sarah Whitcher Kansa, Mark E. Madsen, Jennifer Melcher, Joan Negre, Fraser D. Neiman, Rachel Opitz, David C. Orton, Paulina Przystupa, Maria Raviele, Julien Riel-Salvatore, Philip Riris, Iza Romanowska, Néhémie Strupler, Isaac I. Ullah, Hannah G. Van Vlack, Ethan C. Watrall, Chris Webster, Joshua Wells, Judith Winters, Colin D. Wren

* corresponding author, bmarwick@uw.edu

Introduction

In archaeology, we are accustomed to investing great effort into collecting data from fieldwork, museum collections, and other sources, followed by detailed description, rigorous analysis, and in many cases ending with publication of our findings in short, highly concentrated reports or journal articles. Very often, these publications are all that is visible of this lengthy process, and even then, most of our journal articles are only accessible to scholars at institutions paying subscription fees to the journal publishers. While this traditional model of the archaeological research process has long been effective at generating new knowledge about our past, it is increasingly at odds with current norms of practice in other sciences. Often described as 'open science', these new norms include data stewardship instead of data ownership, transparency in the analysis process instead of secrecy, and public involvement instead of exclusion. While the concept of open science is not

Thanks, got it now



David Orton
10:21 AM Jan 3

Resolve

Worth mentioning data papers somewhere here too? I realise JOAD eventually comes up later on.



Phoebe France
2:08 AM Jan 4

"data accessibility requirements" ?



Ben Marwick
7:36 AM Jan 18

1760 vs 31,600 google results for "data accessibility requirements" vs "data availability requirements", so I think I'll stick with 'availability' as the more familiar term



Joshua Wells
3:59 PM Jan 20

Add paragraph (2 times)



Ben Marwick
12:43 PM Jan 23

Thanks, I think we might save some of these further details about open

1. What is a science?

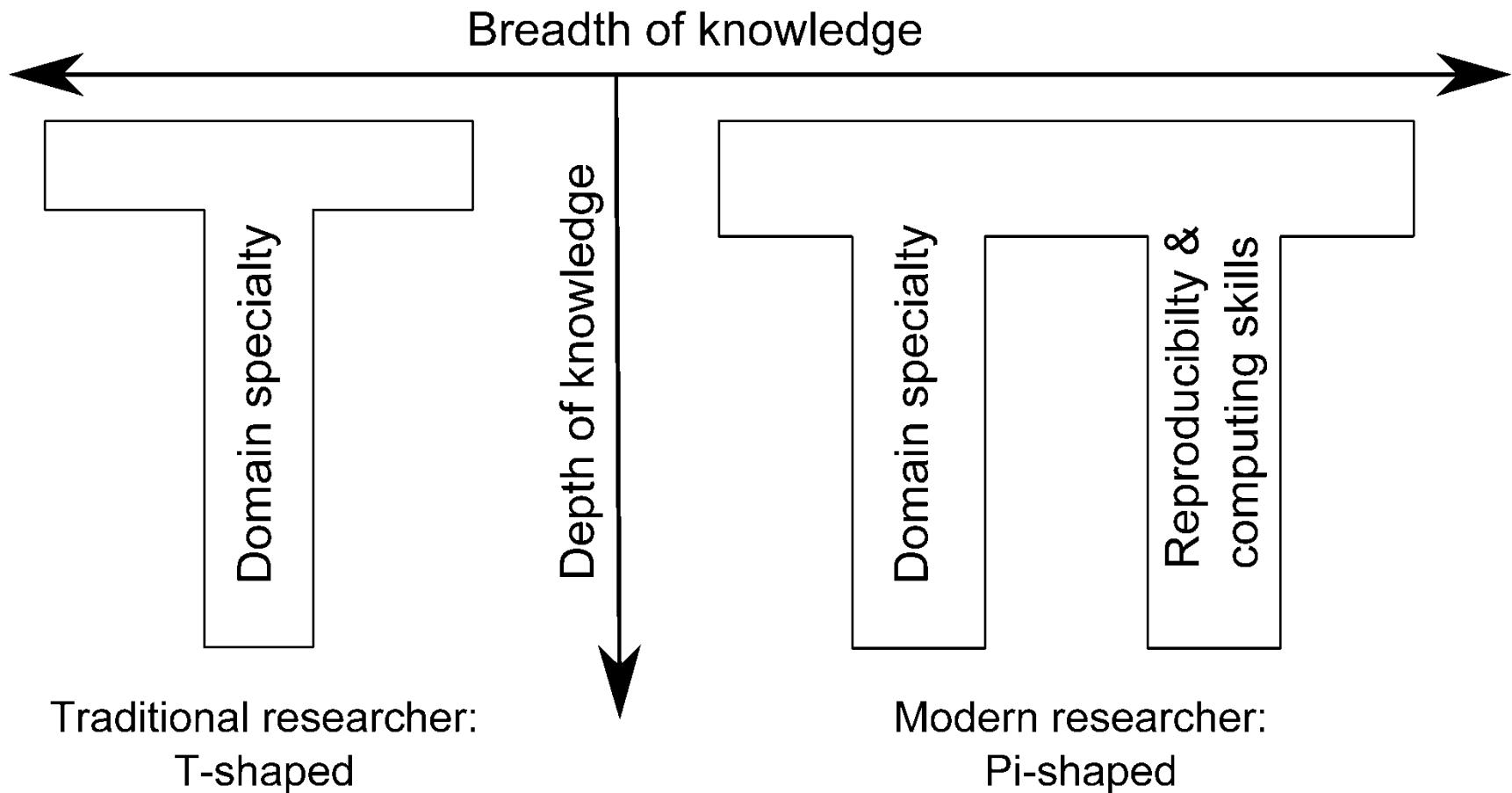
Philosophers of science don't agree about how to demarcate science and non-science

2. Why isn't archaeology a science?

A bibliometric analysis shows that the way we communicate is unlike harder sciences. Because we value privacy & ownership more than other fields

3. How to be a science

A tool-driven revolution to enable transparency and openness.
Cultural change in the research community





weibo.com/perv

THE END



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