A short primer on the academic, societal, and animal welfare benefits of Open Science for animal science

Christian Nawroth[1], E. Tobias Krause[2]

[1] Institute of Behavioural Physiology, Research Institute for Farm Animal Biology,

Dummerstorf, Germany

[2] Institute of Animal Welfare and Animal Husbandry, Friedrich-Loeffler-Institute, Celle, Germany

Both authors contributed equally

Correspondence:

CN: nawroth.christian@gmail.com

ETK: tobias.krause@fli.de

Orcid ID: CN: 0000-0003-4582-4057

ETK: 0000-0002-8327-3711

A significant proportion of research is directly or indirectly supported through public funding. It is therefore imperative to make obtained scientific findings freely accessible and the way this knowledge is generated as transparently as possible. However, the traditional scientific publication system involves a number of obstacles likely to hinder the process of freely available scientific knowledge and transparency by including delays and restricted access in the proliferation of protocols and results, such as pay-walled journals and articles, long reviewing times, publication biases towards novel positive findings, and personal interests (1,2). While many tools are available to improve the transparency and accessibility of the scientific process and the subsequent research findings, the most powerful tool available is likely the implementation of Open Science practices (3). Open Science covers various aspects of the scholarly process, ranging from e.g. Open Access publishing of research articles, to providing Open Data and Protocols, to Open Science Evaluation (open peer review) and Open Science Tools such as Open Source software – with the primary goal of building on, reusing and openly criticizing the (published) body of scientific knowledge.

While in certain research fields such as e.g. psychology or ecology (4), the application of these practices has been assessed and is growing rapidly, their current state and progress in other fields, such as animal science is, to our knowledge, not systematically assessed and implemented. While general academic and societal benefits of Open Science might be apparent (and more or less generalizable across disciplines), we here will further argue that the implementation of Open Science practices will also benefit the field of animal science by a stronger adherence to the 3R principles, to reduce the number of animals in research, refine protocols and methods and replace animals' studies by animal-free alternatives (5).

Why is Open Science important for animal scientists?

Research in animal science involves, often costly, animal experiments that require the housing and testing of animals that can, to a considerable degree, compromise their welfare. As such, these experiments are also under special scrutiny and observation of the legislation and the public. Accessible and transparent research, e.g. via Open Science, offers options to decrease/mitigate some of these conflicts.

We here outline three main reasons for a better implementation of Open Science practices in animal science:

i) From an **academic** point, Open Science can enable researchers to improve the scientific communication and dissemination of test protocols, data and publications that, in turn, can lead to increased efficiency and thus save costs in research, for example via quicker sharing of novel, and identification of outdated, research protocols.

ii) From a **societal** point, knowledge (and the way knowledge is generated) that supports the need for improvements in animal husbandry and management, and measures the success of different interventions in achieving animal welfare goals, need to be accessible and transparent to policymakers, farmers, media and other stakeholder to change and further improve legislation and animal protection laws. Open and transparent reporting of research findings can furthermore help to maintain public trust for science in general.

iii) From an **animal welfare** point, increased transparency of reporting research protocols and findings could lead to a significant reduction in the number of individual animals tested in animal science, thus complying with the 3R principles (Refinement, Reduction and Replacement of animals used in experimental research; ,6), for example via assessment of research protocols before data collection begins. This is especially relevant for research that exposes animals to a certain amount to restricted welfare conditions (see Figure 1).

In light of these three dimensions of reasoning for Open Science, we here will outline in detail three Open Science practices that focus around a) providing a full protocol on what question is ought to be answered, and what data will be collected and analyzed before data collection starts, through **pre-registering** study protocols and submitting Registered Reports; b) the early sharing of research findings, prior to the traditional peer-review, via **preprints**; and c) the accessible and transparent publication of research findings via **Open Access** publishing.

Pre-registrations and Registered reports

Questionable research practices such as p-hacking (i.e. changing statistical methods until a p-value below 0.05 appears) and HARKing (Hypothesising After Results are Known) are highly problematic (7) as they can mislead researchers and the public that a biological relevant effect exists where there isn't any, and can thus undermine scientific integrity of the scientific community. With pre-registrations of studies, and its corresponding protocols and analyses plans, authors can deposit their hypotheses and study designs on pre-registration servers - before they start data collection (8). These pre-registrations can also be submitted to a journal and undergo peer-review – with the resulting article type being called 'Registered Reports'. Comparisons between traditional, non-pre-registered articles and these Registered Reports show that effect sizes of the latter are far below the former – showing that particular biases, such as publication bias, have caused inflation in published effects in traditional, non-pre-registered articles (9,10).

This early documentation of the test and analysis protocol can not only increase the credibility of results, but also increase subsequent publication speed (via Registered Reports). Academics can already receive a provisional acceptance by a journal based on their submitted Registered Report, streamlining the submission and publication process. Early review at this stage can thus reduce the time to make scientific knowledge available as it reduces the amount of time from completion to publication. It should be noted that these pre-registrations have the option to only be made public after a certain embargo, so that the research idea will remain protected. Pre-registration, and Registered Reports in particular, can also ensure that negative results from animal experiments become available to the public.

For society, pre-registrations, and the peer feedback that they can receive when submitted as a Registered Report, can save monetary resources because potential pitfalls in the study design might be identified before data collection begins, and thus can be corrected. Most importantly, however, is that pre-registrations can increase the confidence and trust in scientific findings by the public due to a prior reliable documentation of the test protocol and analysis plan before starting the data collection and analysis.

From an animal welfare point of view, pre-registration allows identification of redundant study designs before data collection starts and thus having a direct impact on the number of animals used in research the potential to contributing to the reduction of animals used in research (11). They can potentially also simplify the work of ethics committees as committee members could use the peer-review recommendations from the Registered Report regarding the scientific rigor and robustness of the study design. Pre-registrations could thus be potentially linked to ethical committees (and ethical approval), streamlining the process of scientific assessment and ethical considerations using experimental animals of a proposed experiment. Depending on national guidelines regarding ethical oversight of animal testing, barriers such as specific bureaucratic hurdles and the language used in these reports need to be assessed in order to find common ground (see Figure 1).

Although the number of journals offering Registered Reports is increasing, not all fields are affected equally by this increase (12); e.g., to our knowledge, no journal dedicated to animal science is currently offering this article type.

Preprints

Peer-review is one of the most important steps for quality control of the scientific literature and is supposed to serve as a key gatekeeper for high-quality science. As crucial as peer-reviewing is at the journal-level, it is often very time consuming and can significantly delay the publication of research findings. Furthermore, if a manuscript is repeatedly rejected by different outlets (e.g. for reasons that are not linked to its scientific merits, including studies that support the null hypothesis), this can lead to additional delays and stretch the peer-review-system to its edges. Ultimately, this can in some cases lead the authors to the decision to not publish their manuscripts at all. During these delays, protocols and data are usually not available and thus hamper the proliferation of this information not only to the scientific community, but also stakeholders in society (such as policy makers and consumer). To make their manuscript available before peer-review, researchers can submit a preprint to a preprint server. Preprints are research manuscripts that are shared openly before or at submission to a journal, i.e. prior to peer-review. Preprint archives assign a digital object identifier (DOI), effectively making them also citable for other researchers.

For academics, the benefits of this preprinting process include the rapid dissemination of academic work, which can facilitate open access to the literature for a wider audience. It also allows fast feedback from peers, which may than be addressed prior to formal peer-reviewing, and thus can facilitate scientific collaborations (13). In terms of scholarly impact, manuscripts submitted as preprints tend to receive later on, when published by a journal, a higher citation count (14). The downloaded numbers of a preprint also predict the journal impact factor of the subsequently published manuscript (15). Some might argue that preprinting will encourage research theft of the initial idea (and/or data) and publish it before the original authors (i.e. ‘scooping’). While this option can ultimately not be excluded, it is extremely unlikely as preprint archives provide a publicly available DOI timestamp to a manuscript. By posting a citable preprint with your research results, a researcher can firmly stake a claim to the work they have done.

For society, preprints offer also benefits: early insights into cutting-edge topics can be picked up (with the given caution that they have not been peer-reviewed yet) by interested lay people or the media, as recently seen in COVID-19-preprints (16). However, clear communication and badges are required that these manuscripts are not yet peer-reviewed and have to be taken with the respective caution. Preprints thus offer an effective way to share novel findings, especially if they affect urgent responses to problems that stakeholders are facing.

Preprints can help from an animal welfare point of view, and with regard to the 3R-principles, to decrease the number of animals used in research by indicating early which protocols have been used (and are likely to be more successful to answer specific questions) and which labs have already done research on a topic of interest (see Figure 1). This likely reduces unintended duplication of research methods that are not suitable to answer a specific question at hand.

Right now, preprinting is allowed by most publishers and journals in the field of animal science. However, with some policies it is often not clear whether they target self-archiving after acceptance of a publication, or actual preprinting before peer review ((17) see also Table 1).

Open Access

Open Access refers to the removal of major obstacles, such as pay-walls or subscription fees, to accessing, sharing, and re-using any output of research. Open Access of papers can be achieved via different routes. The so-called Gold route refers to journals that publish all their articles under an Open Access license, effectively making them freely accessible at the point of publication. This route is accompanied by article processing charges by the journal; thus, the authors need to pay and not the reader. The so-called Green route refers to author self-archiving, in which post-prints of peer-reviewed articles and/or not peer-reviewed preprints are posted online to an institutional and/or subject repository, or to a personal website; there are no financial costs for authors nor for readers via the Green route. This green route is often dependent on journal or publisher policies on self-archiving (see Table 1). Some journals, e.g., allow instant self-archiving of the post-print of a now published, but pay-walled article, on a researcher's own or institutional webpage, effectively increasing proliferation of these findings. Nonetheless, some publishers require an embargo period before deposition in public repositories is allowed (see Table 1).

Many of the major established journals in animal science are, however, adhering to the traditional pay-walled publishing model, with the option to publish with so-called Hybrid Open Access licensing. However, only a relatively small proportion of articles in these journals is published with such Hybrid Open Access licensing, probably because many institutes pay for Open Access only in fully open journals as otherwise institutions have to pay subscription fees and additional article processing fees. All definitions of Open Access type (Gold, Green, Hybrid, Diamond, Bronze, Closed) are described in Piwowar et al. (18).

For academia, Open Access means that research is available to any researcher worldwide, regardless of the economic situation of their institute (19). It also allows researcher to legally share their own work to a wider audience. Furthermore, it seems to pay-off for authors to publish their research with an Open Access license, as first studies show that these items are viewed more often and are cited more often compared to pay-walled articles (20). An issue to be solved in the future are the costs to authors for publishing under an Open Access license; many institutes or universities have specific budgets or contracts for these journals and some funding agencies also provide specific funding for such publishing. However, it is not free to any researcher yet to have such funding available.

The societal impact of Open Access is high, in particular for advocating research to policy makers, advancing citizen science initiatives, media and levelling the playing field for researchers in developing countries (21). Everyone interested can have access to the full paper.

From an animal welfare point, openly available peer-reviewed research papers, protocols, and research data have the potential to reduce the amount of new animal experiments conducted by avoiding redundant designs due to a faster and wider dissemination of the findings. They might also ease meta-conclusions with a potentially smaller number of studies and maybe more heterogeneous results (see Figure 1).

Table 1. Open Science practices in animal science journals – a brief overview: we selected an exemplary and non-representative couple of Hybrid Open Access journals that represent different publishers and cover animal science while not specialized to a certain animal group. We assessed whether Open Access approaches such as pre- and postprinting are supported by the journals and whether they offer the opportunity to submit Registered Reports.

Journal	**Publisher**	**Embargo for post-prints (accepted doc version) according to https://v2.sherpa.ac.uk/romeo/**	**Preprinting possible (according to guidelines for authors and https://v2.sherpa.ac.uk/romeo/)**	**Offers Registered Reports (according to guidelines for authors)**
Animal Science	Cambridge University Press	immediately for author's homepage 12 months for repository	Yes	No
Animal Welfare	Universities Federation for Animal Welfare (UFAW)	12 months	Yes	No
Applied Animal Behaviour Science	Elsevier	immediately for author's homepage 12 months for repository	Yes	No
Journal of Applied Animal Welfare Science	Taylor & Francis Online	immediately for author's homepage 12 months for repository	Yes	No
Journal of Animal Breeding and Genetics	Wiley	12 months	Yes	No
Journal of Animal Science	Oxford University Press	immediately for author's homepage 12 months for repository	Yes	No

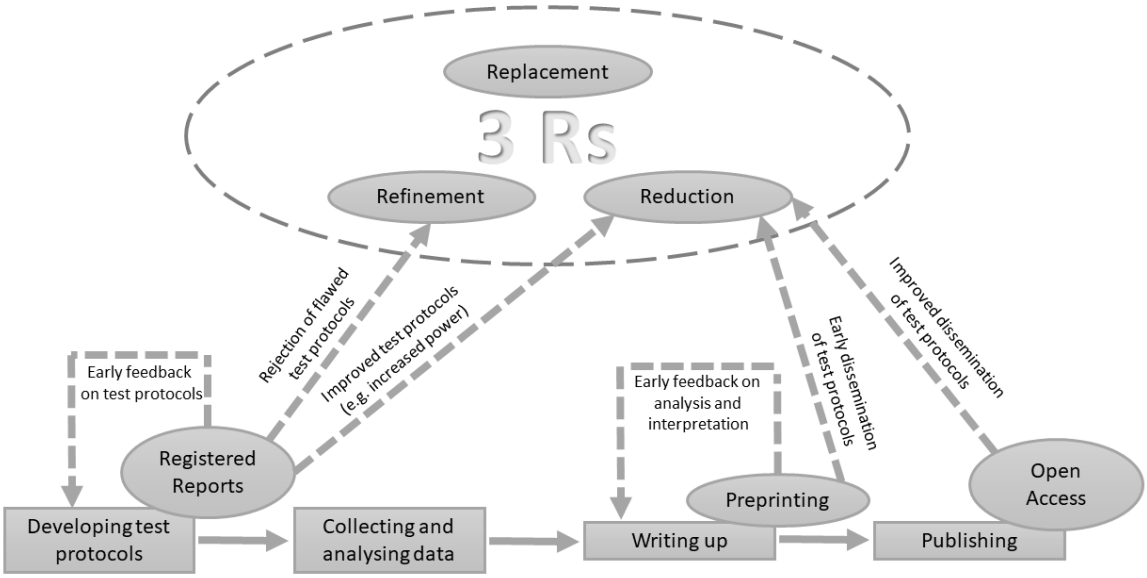

Figure 1 Graphical illustration of potential animal welfare benefits through increased transparency by implementing Open Science practices such as pre-registrations/Registered Reports, Preprinting, and Open Access publishing.

Summary

The benefits of Open Science for general academic and societal issues are relatively generalizable across scientific disciplines. Those have the potential to increase public trust in research findings due to heightened transparency. In addition, animal science, as all research involving experiments with animals, has the obligation to reduce, refine, and replace the usage of animals in research, the so-called 3R-principles. An efficient adherence to these principles would be improved by transparently publishing research findings, data and protocols. This can be accomplished via the means of a variety of Open Science practices. Open Science should thus be considered by animal science researchers as a valuable opportunity that can contribute to the adherence to these 3R principles. We stress the need for future investigations on the crossroads of Open Science and the specific issues that experiments in the field of animal science often face, such as adaptation of test protocols in exploratory research. We also want to encourage animal science researchers to implement a diverse set of Open Science practices in their workflows, a notion that could be most easily implemented by providing workshops and courses in research training for Early Career Researchers (graduate students and early postdocs).

Author contributions

Both authors conceptualized, wrote and edited the manuscript.

Acknowledgments

We thank Anissa Dudde, Sandra Düpjan, Anja Eggert, Antonia Patt, Martin Schmelz and Hanno Würbel for comments on a previous version of the draft. CN was supported by a grant from the Deutsche Forschungsgemeinschaft (DFG, LA 1187/6-1).

References

1. Møller AP, Jennions MD. Testing and adjusting for publication bias. *Trends in Ecology and Evolution* (2001) 16:580–586. doi:10.1016/S0169-5347(01)02235-2
2. Székely T, Krüger O, Krause ET. Errors in science: The role of reviewers. *Trends in Ecology and Evolution* (2014) 29:371–373. doi:10.1016/j.tree.2014.05.001
3. Vicente-Saez R, Martinez-Fuentes C. Open Science now: A systematic literature review for an integrated definition. *Journal of Business Research* (2018) 88:428–436. doi:10.1016/J.JBUSRES.2017.12.043
4. Powers SM, Hampton SE. Open science, reproducibility, and transparency in ecology. *Ecological Applications* (2019) 29:e01822. doi:10.1002/eap.1822
5. Russell WMS, Burch RL. *The principles of humane experimental technique.* London: Methuen & Co. Ltd. (1959).
6. Guhad F. Introduction to the 3Rs (Refinement, Reduction and Replacement). *Journal of the American Association for Laboratory Animal Science* (2005) 44:58–59.
7. Fraser H, Parker T, Nakagawa S, Barnett A, Fidler F. Questionable research practices in ecology and evolution. *PLOS ONE* (2018) 13:e0200303. doi:10.1371/journal.pone.0200303
8. Nosek BA, Ebersole CR, DeHaven AC, Mellor DT. The preregistration revolution. *Proceedings of the National Academy of Sciences* (2018) 115:2600–2606. doi:10.1073/pnas.1708274114
9. Scheel AM, Schijen MRMJ, Lakens D. An Excess of Positive Results: Comparing the Standard Psychology Literature With Registered Reports: *https://doi.org/101177/25152459211007467* (2021) 4: doi:10.1177/25152459211007467
10. Schäfer T, Schwarz MA. The Meaningfulness of Effect Sizes in Psychological Research: Differences Between Sub-Disciplines and the Impact of Potential Biases. *Frontiers in Psychology* (2019) 10: doi:10.3389/fpsyg.2019.00813
11. Steinfath M, Vogl S, Violet N, Schwarz F, Mielke H, Selhorst T, Greiner M, Schönfelder G. Simple changes of individual studies can improve the reproducibility of the biomedical scientific process as a whole. *PLOS ONE* (2018) 13:e0202762. doi:10.1371/journal.pone.0202762
12. Hardwicke TE, Ioannidis JPA. Mapping the universe of registered reports. *Nature Human Behaviour* (2018) 2:793–796. doi:10.1038/s41562-018-0444-y
13. Sarabipour S, Debat HJ, Emmott E, Burgess SJ, Schwessinger B, Hensel Z. On the value of preprints: An early career researcher perspective. *PLOS Biology* (2019) 17:e3000151. doi:10.1371/journal.pbio.3000151
14. Shuai X, Pepe A, Bollen J. How the Scientific Community Reacts to Newly Submitted Preprints: Article Downloads, Twitter Mentions, and Citations. *PLoS ONE* (2012) 7:1–8. doi:10.1371/journal.pone.0047523

15. Abdill RJ, Blekhman R. Tracking the popularity and outcomes of all biorxiv preprints. *eLife* (2019) 8:e45133. doi:10.7554/eLife.45133
16. Majumder MS, Mandl KD. Early in the epidemic: impact of preprints on global discourse about COVID-19 transmissibility. *The Lancet Global Health* (2020) 8:e627–e630. doi:10.1016/S2214-109X(20)30113-3
17. Klebel T, Reichmann S, Polka J, McDowell G, Penfold N, Hindle S, Ross-Hellauer T. Peer review and preprint policies are unclear at most major journals. *PLoS ONE* (2020) 15:e0239518. doi:10.1371/journal.pone.0239518
18. Piwowar H, Priem J, Larivière V, Alperin JP, Matthias L, Norlander B, Farley A, West J, Haustein S. The state of OA: A large-scale analysis of the prevalence and impact of Open Access articles. *PeerJ* (2018) 2018:1–23. doi:10.7717/peerj.4375
19. Kriegeskorte N, Walther A, Deca D. An emerging consensus for open evaluation: 18 visions for the future of scientific publishing. *Frontiers in Computational Neuroscience* (2012) 6:94. doi:10.3389/fncom.2012.00094
20. Piwowar H, Priem J, Orr R. The Future of OA: A large-scale analysis projecting Open Access publication and readership. *bioRxiv* (2019)795310. doi:10.1101/795310
21. Tennant JP, Waldner F, Jacques DC, Masuzzo P, Collister LB, Hartgerink CHJ. The academic, economic and societal impacts of Open Access: An evidence-based review. *F1000Research* (2016) 5:1–55. doi:10.12688/f1000research.8460.1