Five Creative Ways To Promote Reproducible Science

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Standfirst: The importance of reproducible scientific practices is widely acknowledged. However, limited resources and lack of external incentives have hindered their adoption. Here we explore some innovative ways to promote reproducible science in practice.

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It has been more than a decade since the recognition that the results of many scientific studies fail to replicate. In the wake of the initial acknowledgment of the "replication crisis", growing number of scientists now recognize the importance of reproducible scientific practices and are motivated to use them[1]. Still, despite these internal motivations, many struggle with their implementation due to limited resources and the lack of external incentives. Indeed, major structural changes to the ways scientific research is funded, published, recognized, and evaluated are required to ensure optimal implementation of reproducible scientific practices. Nevertheless, smaller scale initiatives could help to rapidly improve scientific research across fields and serve as catalysers for major transformations.

Here, we describe five focused solutions to incentivize and lift barriers to reproducible science. Some of the ideas described here are not novel, and indeed have already been implemented in some fields or institutions. Our objective here is to provide a consolidated perspective on creative ways to promote reproducibility and awareness of these strategies within the broader scientific community.

1) Funded project extensions to post-graduate (PGR) students

Adopting open science practices is time consuming and might delay project progression[2]. For example, publishing a study as a Registered Report (RR) might extend the project due to two separate peer-review stages, as well as (in some cases) requiring longer data collection duration due to higher power requirements. This can pose significant barriers to RR adoption for PGRs whose funding lasts for prespecified (often short) amount of time.

A funded project extension given against evidence of engagement in reproducible practices would lift this barrier. The scope of these activities might include, for example, evidence of code and data sharing, running a replication study, preregistering the experimental protocol (e.g., as RR or on platforms such as the Open Science Framework), and more. These activities do not need to take place during the extension (and indeed, to be granted an extension, students should be able to provide evidence indicating that some activities have already occurred). This approach will allow PGRs to avoid a bottleneck towards the end of the course and enable better planning of these activities. It will allow PGRs to develop adequate skills, and would support them in pursuing reproducible science, without needing to 'sacrifice' their limited contracted time for this purpose.

2) Guaranteed funding for Registered Reports

A central barrier to the implementation of Registered Reports (RR)[3], is that when a Stage 1 RR is submitted for peer-review, authors must be able to guarantee that funding for the project has been secured. Whilst this requirement is reasonable (and indeed necessary) from the journal's perspective, it adds barriers to the ability of researchers to pursue this option. Namely, securing funding for a full research project is time consuming. When this adds to the extra time required for RRs, registration often becomes infeasible, especially for researchers with short fixed-term contracts and/or significant workload. Nevertheless, from the funders' perspective, funding an RR should be highly desirable and can be viewed as "low risk, high gain": a Stage 1 RR has already been accepted for publication, and would therefore undoubtfully produce outcomes.

Therefore, both funders and scientists could benefit from a novel funding model that incorporates RRs into the funding structure. We are proposing the allocation of funding for smaller scale projects which would be submitted as RRs. With this, projects submitted as RRs can receive guarantee that they will be funded if accepted. For example, external funders and academic institutions can allocate funding to support accepted RRs. As such, researchers aiming to submit a Stage 1 RR will apply for funding, and if successful, receive a guarantee for funding once the study protocol is approved, i.e., when In Principle Acceptance (IPA) is obtained. Another possible mechanism for this adheres to (and indeed, can be integrated with) the Peer Community In (PCI) RR initiative, in which RRs are reviewed by the community (i.e., both IPA and a final Stage 2 approval are granted by communal peer-review), and are then published in PCI-friendly journals without further peer-review[4]. An extension of this would be to designate PCI-friendly funders, who commit to fund projects for which IPA was obtained via PCI. To realize these solutions, eligibility and assessment criteria (e.g., projects' scope), as well as intake load (e.g., costs and number of concurrently funded projects), should be pre-defined on a funder-by-funder basis, to avoid a situation in which funders\institutions are committed to more projects than they can support. Nevertheless, this proposal will allow funders to allocate some of their funds to accepted projects which were thoroughly reviewed and judged to be worthwhile by relevant experts within the scientific community.

3) Reproducible science centralized knowledge base and "helpline" by discipline

Recent surveys have shown that a key challenge to performing reproducible science is lack of knowledge and centralized resources[5,6]. Therefore, scientists will greatly benefit from communal support on reproducibility that targets their particular discipline. Best practices, procedures, and data types vary dramatically across disciplines, and hence also the kind of support and solutions that are required. A specialized centralized knowledge base and "helpline" can be established for this purpose, that will serve as a main contact point for scientists who wish to engage with reproducible science practices within their discipline.

Such resources could be, and indeed have been, collaboratively developed by researchers from the field who are actively developing or promoting reproducible science practices, integrating their knowledge into a centralized resource[7] (see here for an example in neuroimaging). "Helplines" could take the form of Q&As covering the main questions and challenges researchers from the field face when attempting to adapt reproducible science practices. Additionally, they should include online chats, with experts from the field and / or AI-based tools (or, if not possible, offline forums can be used to facilitate communication between researchers in the field, assisting each other when facing problems; see here for an example in neuroimaging). A collection of case studies showing how engagement in reproducible practices can benefit career progression of Early Career Researchers (ECRs) would also be beneficial for motivating other researchers to employ them. The forum could also offer an opportunity for exchange of teaching materials on reproducible practices and therefore aid in fostering better training in this area. Reproducibility experts in the field should be incentivized to contribute to such efforts, preferably through funding[8], but also through societal recognition and scientific credit. Furthermore, researchers who benefit from these resources could be encouraged to "pay it forward" by contributing to the knowledge base and helping other researchers.

4) Institutional/departmental contact point for reproducible research practices

In addition to the "global" contact point described above, scientists will also benefit from a local contact point, within their institutions, which will have more specific knowledge and experience within specific locations (e.g., data sharing or open access options are different in different countries). Currently, some institutions or departments nominate individuals to serve as "Open Science champions" or to take up similar roles to support reproducible practices. However, these are usually designated as (often unofficial) admin roles that add to current workload. It is extremely rare for institutions to create a position for a person who will be dedicated to these issues (but see for example Tanenbaum Open Science Institute at McGill University, and the Psychology Department at the University of Sussex). However, a dedicated position can ensure that sufficient time is allocated to this purpose, and that the person in charge has the required expertise.

The job specification and career progression for such a role will need to be considered by the individual departments and institutions, but might include in depth understanding of the publication system (open access etc.), technical understanding of data and code sharing, code and statistical verification, pre-registration, and so on. Although some of these functions are already partially fulfilled by existing positions (e.g., librarians), an overall understanding of the various aspects required to achieve reproducible science is lacking. Furthermore, experience in conducting research by the point of contact will facilitate communication with other researchers and understanding of the barriers. In the long term, a position like this can significantly decrease the time that individual researchers spend navigating these issues. In addition, the point of contact can develop courses, hands-on workshops and resources to further facilitate the implementation of reproducible science practices in the department/institution.

5) Creating and maintaining a reproducible science portfolio

Implementation of reproducible science practices (such as code and data sharing) can help develop important transferable skills, that are required and encouraged in many industries and across scientific disciplines[9]. Early on consideration of these skills allows ECRs to develop a convincing portfolio that can be harnessed when applying for jobs within and outside of academia. However, it is sometimes hard to understand how to "showcase" these skills in different contexts and ensure that they are not only realized but also recognized. As such, it is also of key importance that supervisors, departments, and university career teams fully appreciate the importance of these skills for proficiency and employability, support their development, and provide guidance to optimize their presentation to potential employers. For example, schemes such as 'CRediT'[10] or 'All Contributors' have created taxonomies of contributions that can be used to show one's experience with specific aspects of research projects or open-source coding projects respectively. A similar taxonomy could be developed for open science practices to allow individuals to highlight their specific skills in this area. Career teams can then support students in embedding this important information into their CVs and narrative statements. This will increase the motivation for scientists and ECRs in particular to engage in reproducible practices, and will also ensure appropriate support to benefit their prospective careers.

All of these proposed initiatives would need to be supported by adequate changes to funding and administrative structures. Table 1 links each of the ideas above to specific resources (mainly funding and personnel) that should be allocated to support it. Nevertheless, while most of these ideas would require some initial investment of resources, we argue that they can potentially reduce costs in the long run. For example, funding projects that received IPA following peer-review by experts can spare funders' need to provide panel/peer-review. Similarly, having a person who supports reproducible science within institutions would reduce the time spent by individual scientists on tackling these issues and thus increase efficacy and productivity. It is also of note that most of these ideas are best implemented conjointly. For example, a reproducibility expert within a department can also aid PGRs in implementing reproducible practices within their project and evaluate whether they are eligible for a paid extension.

To conclude, the implementation of practical creative solutions, even at relatively small scales, can accelerate the adoption of reproducible scientific practices.

Table 1. A summary of 5 proposals for incentivizing reproducible science

What	Who	How	Why
Project extension	Postgraduate students (PGRs)	• Funds allocated via departments and/or training centres (depending on specific contracts). • Extensions are considered by a departmental representative / supervisor / PhD committee, against evidence provided by the student.	• The extra time investment often needed to engage in reproducible research makes it difficult for postgraduate students on fixed short-term contracts to engage in reproducible research. • As such many postgraduate students who do so need to extend their project anyway, but this extension is often unpaid.
Funding Registered Reports (RRs)	All scientists, mainly Early Career Researchers (ECRs)	• Funds allocated via departments or external funders. • Funders will need to provide guidelines and assess projects' suitability (e.g., scope, eligibility, intake load). However, in-depth peer-review will be provided through the process of obtaining In Principle Acceptance (IPA), and therefore does not impose additional overheads to funders.	• To get a Stage 1 approval for a RR, one needs to indicate that funding has been secured. • At the same time RRs that have been given Stage 1 approval are a "safe bet" for funders as the study will be published regardless of results.
Centralized support	All scientists (discipline based)	• Possibly supported by discipline-specific funders (such as the various UK Research and Innovation	• Would save time spent searching for best practice individually and therefore ease and improve

		branches or the German Research Foundation). • Requires communal effort – initial setup by expert and reproducibility supporters; continuous maintenance further assisted via a "pay it forward" approach.	application of reproducible research practices. • Can act as a training resource showcasing the "gold standard" in reproducible practices.
Departmental support	All scientists (location / institution based)	• Funds for specialized roles should be allocated by institutions / departments. • The person holding the position will be in close contact with other relevant bodies within and outside the institution.	• Would save time spent searching for best practices and would create a dependable source of information regarding location-specific practices. • Would promote other solutions, such as aiding postgraduate students with effective implementation of reproducible practices in their research.
Portfolio	Postgraduate students / Early Career Researchers	• Career teams / supervisors / PhD committee should be able to support the preparation of the portfolio	• Aids postgraduate students and Early Career Researchers in harnessing and showcasing their specific skillset to potential employers.

Note: Each idea ('What') is linked to the main beneficiary ('Who'), key resources that should be allocated to support its implementation ('How'), and key benefits of the implementation of the idea ('Why').

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Competing Interests

The authors declare no competing interests.

References

1. Christensen, G. et al. *Open Science Practices are on the Rise: The State of Social Science (3S) Survey,* https://escholarship.org/uc/item/0hx0207r (2020).
2. Allen, C. & Mehler, D. M. A. *PLOS Biol.* **17**, e3000246 (2019). https://doi.org/10.1371/journal.pbio.3000246

3. Chambers, C.D., Dienes, Z., McIntosh, R. D., Rotshtein, P. & Willmes, K. *Cortex* **66**, A1–A2 (2015). http://dx.doi.org/10.1016/j.cortex.2015.03.022
4. Eder, A.B. & Frings, C. *Exp. Psychol.* **68**, 1–3 (2021). https://doi.org/10.1027/1618-3169/a000512
5. Houtkoop, B.L. et al. *Adv. Methods Pract. Psychol. Sci.* **1**, 70–85 (2018). https://doi.org/10.1177/2515245917751886
6. Paret, C. et al. *NeuroImage* **257**, 119306 (2022). https://doi.org/10.1016/j.neuroimage.2022.119306
7. Niso, G. et al. *NeuroImage* **263**, 119623 (2022). https://doi.org/10.1016/j.neuroimage.2022.119623
8. Rahal, R.-M. et al. *Nat. Hum. Behav.* **7**, 164–167 (2023). https://doi.org/10.1038/s41562-022-01508-2
9. Stodden, V. et al. *Science* **354**, 1240–1241 (2016). https://doi.org/10.1126/science.aah6168
10. Holcombe, A.O. *Publications* **7**, 48 (2019). https://doi.org/10.3390/publications7030048