Big team science challenges the scientific community to reconsider the meaning of authorship

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Standfirst: Big team science challenges researchers to revisit three issues around authorship: (1) What is an authorship-worthy contribution, (2) How should contributions be documented, and (3) How should disagreements among large teams of co-authors be handled? We propose steps that the community can take to resolve these issues.

Authorship is the coin of the scientific realm. It's the currency that drives decisions about who we hire, promote, fund, and publicly celebrate. Despite its widespread use, the meaning of this currency has long been debated. These debates are easy to forget in our day-to-day transactions—until, that is, a circumstance forces them back into our attention. We write this commentary because the most recent of these circumstances is occurring today: the proliferation of big team science[1].

Big team science refers to endeavors where an unusually large number of researchers come together in pursuit of a common goal. It's the type of science that has led to the mapping of the human genome, the discovery of the Higg's boson particle, and evaluations of the replicability of research from entire disciplines. But it's also the type of science that has led to atypical authorship dynamics; author bylines can contain hundreds of names, disagreements among collaborators can persist post-publication, and it can be difficult to determine exactly how everyone contributed to the final product. These dynamics are forcing researchers to revisit a fundamental question: how should we structure scientific authorship?

Debates about the structure of authorship have immediate implications for the authorship status of the dozens (or even hundreds) of collaborators working on any given big team science

project. More broadly, these debates impact the economics and fairness of *all* scientific endeavors. For example, if creating architectures that make project data FAIR (Findable, Accessible, Interoperable, and Reusable) is not an authorship-worthy contribution, it will be difficult to incentivize researchers to develop and share expertise in this domain.

In this commentary, we highlight three ways that big team science challenges conventional notions of authorship. Throughout, we discuss steps and potential reform in authorship policies that would better support researchers engaging in these ultra-collaborative research endeavors (Table 1).

Authorship-worthy contributions

. Role specialization is common in big team science, and authorship has been granted to large groups of researchers whose primary role has been to collect data through an online experiment[2], develop statistical models to predict children's life outcomes[3], define open research terminology via community consensus[4], examine different ways of testing hypotheses with fMRI datasets[5], and propose research guidelines[6]. Most agree that these types of contributions are valuable; however, there is no consensus regarding which (if any) warrant authorship.

Should authorship be based on the amount of time spent on a project? The type of task completed? The extent to which the project would be feasible without a collaborator's involvement? Or something entirely different? Unfortunately, policies and norms around these questions vary considerably across research teams, institutions, disciplines, and cultures. For example, the International Committee of Medical Journal Editors recommends that authors should meet *all* the following criteria: (1) make a substantial contribution to writing, (2) make a substantial contribution to any non-writing components of the project, (3) approve the final manuscript, and (4) agree to be accountable for *all* aspects of the work. Other journals, however, do not necessarily require authors to directly contribute to writing or assume accountability for all aspects of the project. Furthermore, some big team science initiatives, like the Framework for Open and Reproducible Research Training, are committed to crediting all contributions—regardless of size or impact.

If authorship is the coin of the scientific realm, disagreements about what constitutes authorship reveal its ambiguous value. Such ambiguity is concerning because it can amplify the impact of pre-existing assumptions and biases[7], which may prove disproportionally harmful for under-represented and early career researchers. We thus suggest that policy makers convene to reconsider and clarify what constitutes an authorship worthy contribution (Table 1). These future policies should more inclusively recognize the various roles that researchers can fill (e.g.,

data curation, software development, project management)—roles that are particularly important and challenging in the domain of big team science.

Documenting contributions

At the end of your favorite film, you will see a long list of credits. These film credits have been common since the 1970's, but it is only recently that similar models have been standardized and popularized in science. For example, in 2014, Allen and colleagues introduced the Contributor Roles Taxonomy (CRediT), which contains 14 categories that allow researchers to describe their specific role on a project[8]. This taxonomy, for instance, allows a researcher to indicate that they contributed to data analysis and visualization, but not writing or editing. The taxonomy further opens the possibility of databases that describe not only which projects researchers were involved in, but also their specific roles—much like the Internet Movie Database (IMBd) does for film.

Many big team science initiatives have championed contributorship taxonomies, especially because they help identify the people who fill increasingly specialized but traditionally undervalued roles, like project management. However, the rise of big team science has also highlighted the logistical challenges of scaling up contributorship taxonomies. For example, to examine how people form impressions of others based on facial appearance, 243 researchers recently came together to collect data in 44 countries[2]. Centrally tracking exactly what each collaborator did would have required a substantial investment in activity-tracking infrastructure. In lieu of such infrastructure, the researchers did the next best thing: they simply asked people to describe their contributions.

Self-reported contributions are standard in big team science. However, like any self-report measure, their values can be distorted. So-called "parachute researchers'' may fail to acknowledge the contributions of international collaborators, especially those from low- or middle-income countries. On the other hand, "free-riders" may exaggerate the extent to which they contributed to a research effort. Such scientific misconduct certainly was not born in big team science, but it is possible that these larger endeavors could prove to be fertile grounds for questionable authorship practices.

To address these issues, stakeholders should consider several proposals. These might include (a) investing in infrastructure that makes activity-tracking easier and better organized (e.g., data depositing trackers), (b) funding meta-science research that investigates the extent to which questionable authorship practices occur in big team science (e.g., both under- and over-reporting of contributions), and (c) developing policies that emphasize the importance of accurate and fair recognition of research contributions (Table 1).

Handling author disagreements

Dissent is healthy in science. However, as the size of a collaboration gets larger, the probability that you will disagree with your own co-authors increases. Some big team science collaborations are designed to be consensus-reaching, but consensus also becomes more difficult as the number of co-authors increases[10]. Adversarial collaborations are also invaluable but post significant questions: what if disagreements cannot be resolved? Dissenting authors would either have to co-author a paper they do not endorse - a violation of policies and norms around authorship - or walk away with not credit for their work.

The Many Smiles Collaboration, which brought together a large adversarial team of researchers to test a controversial idea in psychology called the facial feedback hypothesis[9], proposed a solution: dissenting opinions. The paper would summarize the majority opinion, and dissenting opinions would be organized in a supplement. Ultimately, the supplement was not needed because disagreements were minor enough to be described in the main text. Nonetheless, the dissenting opinion contingency plan helped collaborators feel confident that their participation would be recognized and rewarded even if major disagreements could not be resolved.

Like Issue 1, Issue 3 requires stakeholders to clarify the meaning of scientific authorship. We suggest that authorship should not imply agreement with all aspects of a project. Furthermore, we propose that journals offer a dissenting opinion model—especially for collaborations that are adversarial and/or large. Researchers who lead big team science collaborations may also consider identifying a project-specific (as opposed to institution-specific) ombudsperson, who can serve as a neutral mediator when collaborators navigate particularly contentious disagreements (Table 1).

Table 1. Three common issues and proposed reform in big team science authorship.

Issue	**Proposal**
Big team science has highlighted that researchers disagree about what constitutes an authorship-worthy contribution**.**	Policy makers should convene to develop a more unified set of authorship recommendations. Recommendations must be cognizant of the existing power and privilege imbalances in academia.
It is challenging to accurately document author contributions in big team science.	In partnership with underrepresented researchers, infrastructure and guides should be developed that make research activity tracking easier and better organized.

	Meta-scientific research should examine (a) the prevalence of questionable authorship practices in big team science, and (b) ways to foster equitable partnerships with underrepresented researchers. Policy makers should develop authorship recommendations that emphasize the importance of accurate and equitable recognition of research contributions.
Disagreements are increasingly likely to occur as collaborations become larger.	Agreement with all aspects of the project should not be necessary for co-authorship. Journals should permit dissenting opinions (e.g., as uploaded supplemental materials that are linked to the main text). Big team science collaborations should consider identifying a project-specific ombudsperson.

Concluding Remarks

Some of science's most difficult questions are simply unanswerable without big team science. However, the recent proliferation of this collaborative model has reopened debates about the meaning of the coin of the scientific realm: authorship. The case studies we reviewed indicate a scientific economy in need of reform. Stakeholders, thus, must work together to develop (1) a shared understanding of the meaning of scientific authorship, (2) tracking infrastructure and meta-science research on scientific contributions, and (3) mechanisms for navigating and recognizing disagreements among collaborators (Table 1). These discussions and our proposed reforms may seem costly. However, if we hope to continue to reap the rewards of big team science, we must spare no expense in authorship reform.

References

1. Coles, N. A., Hamlin, J. K., Sullivan, L. L., Parker, T. H. & Altschul, D. Build up big-team science. *Nature* **601**, 505–507 (2022).
2. Jones, B. C. *et al.* To which world regions does the valence-dominance model of social perception apply? *Nat. Hum. Behav.* (2019).
3. Salganik, M. J. *et al.* Measuring the predictability of life outcomes with a scientific mass collaboration. *Proc. Natl. Acad. Sci. U. S. A.* **117**, 8398–8403 (2020).
4. Parsons, S. *et al.* A community-sourced glossary of open scholarship terms. *Nat. Hum. Behav.* **6**, 312–318 (2022).
5. Botvinik-Nezer, R. *et al.* Variability in the analysis of a single neuroimaging dataset by many teams. *Nature* **582**, 84–88 (2020).
6. Lakens, D. *et al.* Justify your alpha. *Nat. Hum. Behav.* **2**, 168–171 (2018).
7. Payne, B. K., Vuletich, H. A. & Lundberg, K. B. The bias of crowds: How implicit bias bridges personal and systemic prejudice. *Psychol. Inq.* **28**, 233–248 (2017).
8. Allen, L., Brand, A., Scott, J., Altman, M. & Hlava, M. Credit where credit is due. *Nature* **508**, 312–313 (2014).
9. Coles, N. A. *et al.* A multi-lab test of the facial feedback hypothesis by the Many Smiles Collaboration. *Nat. Hum. Behav.* **6**, 1731–1742 (2022).
10. ManyBabies Consortium. Quantifying sources of variability in infancy research using the infant-directed-speech preference. *Adv. Methods Pract. Psychol. Sci.* **3**, 24–52 (2020).

Competing interests

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