THE ROYAL SOCIETY

Science 2.0 Consultation: Royal Society response

Introduction

1. The Royal Society welcomes the opportunity to respond to the European Commission's consultation 'Science 2.0' as a funder of researchers, an academic publisher and national academy of science in the UK.

2. This consultation response is mainly based on the Royal Society's report *Science as an open enterprise*[1], which focused on making data open, and consultation responses on Open Access policies[2] .

3. The Royal Society has observed and commented on a paradigm shift in the way that science is being conducted and communicated, and has recommended the development of appropriate incentives and e-infrastructure to ensure that research culture shifts to reflect these developments.

4. Driven by these developments, the nature of scholarly scientific communication is changing too. In 2015, the Royal Society will celebrate the 350th anniversary of the launch of the world's first science journal, *Philosophical Transactions* and is organising a series of open debates about the future of scholarly communication.

A paradigm shift in science

5. Science has benefited from open practices throughout history. Publishing scientific theories, including experimental and observational data, permits others to scrutinise them, to replicate experiments and to reuse data to create further understanding. It permits the identification of errors and allows theories to be rejected or refined. Sustained and rigorous analysis of evidence and theory is the most robust form of peer review. It has made science a self-correcting process since the first scientific journals were established. In recent decades, as the volume of data being produced grew it was not always possible to publish academic papers alongside the supporting data. However, technology can now enable that openness in science.

6. Open science offers public and civic, economic and international benefits. Making data open can improve public engagement, enabling the public to engage more easily in the process and results of science. The importance of a good relationship between science and society has been highlighted by the President of the Royal Society, Sir Paul Nurse FRS, who has said that better discussion and engagement about science with the public will lead to more trust in science.[3] Making data open also offers opportunities to increase the transparency, and communication of research findings. Openness

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[1] https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/sape/2012-06-20-SAOE.pdf

[2] https://royalsociety.org/policy/projects/science-public-enterprise/Report/ and https://royalsociety.org/~/media/policy/Publications/2013/open-access-lords-committee/20130118-jp-open-access-hol.pdf

[3] Sir Paul Nurse (2014), Parliamentary Links Day Speech. Available at: http://blogs.royalsociety.org/in-verba/2014/06/26/paul-nurse-speaks-on-trust-in-science/

should be the default for research unless precluded by fundamental ethical and legal requirements (such as privacy, security, safety and confidentiality).

7. Data-intensive science is also becoming a driver for economic growth and development. Businesses are harnessing open data, and the value of UK data equity is predicted to be worth £216bn in the period 2012-17.[4] However, data-intensive science and its applications must be nurtured and promoted in order for them to become drivers for economic growth and development.

Intelligent Openness

8. Open science requires the effective communication of data: they must be accessible and readily located; they must be intelligible to those who wish to scrutinise them; they must be assessable to that judgments can be made about their reliability and the competence of those who created them, and they must be supported by explanatory metadata (data about data). As a first step towards intelligent openness, data that underpin a journal article should be made concurrently available in an accessible database.

9. Intelligent openness is the optimal way to achieve open data. The first joint G8 Science Ministers and Presidents of national academies of sciences meeting in 2013[5] outlined that for the system of open data to work, data must be:
    a. Discoverable
    b. Accessible
    c. Intelligible
    d. Assessable
    e. Usable

10. Making data intelligently open for the public should initially focus on areas of research which are in the public interest, within legitimate limitations on openness such as commercial embargo, security and safety issues.

Challenges and barriers

11. Appropriate incentives need to be in place if scientists are to adopt open data practices. Those incentives should include access to grant funding, access to publication opportunities, promotion and recognition. These incentives lie in the hands of a variety of institutions:
    a. Grant giving bodies should require data to be intelligently open as a condition of continued funding.
    b. Publishers of research should require data to be made intelligently open as a condition of publication.
    c. Universities and other employers of scientists should include the publication of data and data sharing as criteria for recognition and promotion.

12. There should be a greater focus on skills for managing data. This is becoming all the more important with increasing interdisciplinarity of science, which relies on more effective collaboration and data sharing. Such collaboration and data sharing can be fostered by the creation of online

[4] CEBR (2012). Data Equity: unlocking the value of big data. Available at: http://www.sas.com/offices/europe/uk/downloads/data-equity-cebr.pdf

[5] G8 Science Ministers Statement: https://www.gov.uk/government/news/g8-science-ministers-statement

fora and digital platforms where scientists can share their ideas and question research. 'myExperiment' is an example of this. Other tools that facilitate data sharing for scientists include Figshare, which enables immediate pre-publication data to be shared amongst scientists through a web-based portal, including the sharing of negative results or results that would not otherwise be published.

13. There should be greater support for scientists in the transition to a system where data management skills are necessary. For example, the US National Science Foundation issued a $2 million award for undergraduate training in complex data, and universities such as Southampton and Edinburgh provide courses to train highly skilled data professionals.

14. Realising an open data culture requires an understanding that sharing research data can be complex and costly, and must be enabled by realistic estimates of demand for those data. There must be recognition of the ways in which research data are managed, and the demands that lead to these differing levels of curation.

15. The intelligent use of data requires the effective management of datasets, and protecting privacy of research. Datasets should be managed according to a system of proportionate governance. This means that personal data is only shared if it is necessary for research with the potential for high public value. The type and volume of information shared should be proportionate to the particular needs of a research project, drawing on consent, authorisation and safe havens as appropriate. The decision to share data should take into account the evolving technological risks and developments in techniques designed to safeguard privacy. In relation to security and safety, good practice and common information sharing protocols based on existing commercial standards must be adopted more widely. Any guidelines should reflect that security can come from greater openness as well as from secrecy.

16. Scientists should play a major role in curating and sharing their data. Universities and research institutes are key to supporting an open data culture by seeing open data as the default position. They can assist by recognising data communication by their researchers and supporting the data needs of the researchers. In doing so they can help create the infrastructures in which researchers can make open data flourish.

Opportunities and potential

17. The effective management of open data can support opportunities for discovery in other fields of science. To facilitate these opportunities, scientists should communicate the data they collect and the models they create,, in ways that are intelligible, assessable and usable to allow free and open access for other specialists in the same or linked fields wherever they are in the world. Where data justify it, scientists should make them available in an appropriate data repository.

18. Governments should recognise the potential of open data and open science to enhance the excellence of the science base. They should develop policies for opening up scientific data that complement policies for open government data, and support the development of the software tools and skilled personnel that are vital to the success of both. The European Commission should encourage governments to do so across Europe and move to making Europe a hub of scientific collaboration and openness.

19. Open science also offers international opportunities. The scientific world is becoming increasingly interconnected, and international collaboration is growing. The Royal Society's report *Knowledge, Networks and Nations* estimates that over 35% of articles published in international journals are internationally collaborative.[6] Collaboration enhances the quality of scientific research, improves the efficiency and effectiveness of that research, and is increasingly necessary, as the scale of budgets and research challenges grow. Nonetheless, scientists are the primary driver in this collaboration, forming networks that span the globe. Motivated by the bottom-up exchange of scientific insight, knowledge and skills, they are changing the focus of science from the national to the global.

The Future of Scholarly Communications

20. The nature of scientific publication and scholarly communication is changing. In 2015, the Royal Society will be celebrating the 350th anniversary of the launch of *Philosophical Transactions,* the world's first scientific journal. This is an opportunity to reflect on how scientific publishing has changed over the past 350 years.

21. *Philosophical Transactions* pioneered the concepts of scientific priority and peer review, enabling the progress of science by creating a mechanism for the dissemination and archiving of discoveries for the first time. The nature of scholarly scientific communication is changing because of new developments in the publishing landscape (many of which are the result of opportunities offered by the web). The main areas of controversy and development are; the process of peer review, the concept of open science, reproducibility of results, the measurement of impact and reward, changing business models and the issue of misconduct. The open debates organised as part of the anniversary will enable researchers, publishers, funders, librarians and policy makers to discuss the future development of science and scientific publication at a time of great change.

The UK example

22. In the UK, different organisations have communicated the benefits of open data. This has included bodies such as the British Science Association, Nuffield Foundation and the Wellcome Trust, who have facilitated the debate of open data to inform the public on the subject. Learned societies can play a complementary role in providing technically accurate, scientifically honest and readable accounts of what 'public interest science' is.

23. If the benefits of open science are spread to new areas of research, the system of reward and promotion in universities and institutes must do more to recognise those who develop and curate datasets. This would provide an incentive to participate in these new research practices. Open data should be a default position for universities and research institutes. Practices for the assessment of university research should reward the development of open data on the same scale as journal articles and other publications, and should include measures that reward collaborative ways of working.

24. The Royal Society operates an 'open access' policy and is committed to the widest possible dissemination of research outputs. It is a condition of publication in Royal Society journals that authors make available the data and research materials supporting the results in the article. Datasets should be deposited in an appropriate, recognised repository. The link to this repository must be included in the methods section of the article, and references to the dataset should be clearly

[6] Royal Society (2011). Knowledge, Networks and Nations. Available at: https://royalsociety.org/policy/projects/knowledge-networks-nations/report/

included in the reference list of the article. Where possible any other relevant research materials should be made available, and details of how they may be obtained should be included in the methods section of the article. Authors are required to disclose upon submission of the manuscript any restrictions on the availability of research material or data.

25. Collaboration is important to open science. For example, the Royal Society is part of a project with the Nuffield Council on Bioethics focusing on research culture, including issues such as research misconduct, the practice of science and trust.[7] The project looks at the evolving nature of scientific research, and how to ensure that research culture fosters ethical conduct in science and the production of high quality, valuable, accessible research.

A European Opportunity

26. Is there a conflict between the interests of taxpayers of a given state and open science where the results reached in one state can be readily used in another? Researchers in one state may test, refute, reinforce and build on the results and conclusions of researchers in another. This international exchange often evolves into complex networks of collaboration and stimulates competition to develop new understanding. As a consequence, the knowledge and skills embedded in the science base of one state are not only those paid for by the taxpayers of that state, but also those absorbed from a wider international effort. Trying to control this exchange would risk yet another "tragedy of the commons", where myopic self-interest depletes a common resource, whilst the current operation of the internet would make it almost impossible to police. This move towards open data would therefore benefit the whole of Europe, and have the opportunity to lead and demonstrate to the world the benefits of intelligent openness in research.

Conclusion

27. The Royal Society welcomes the moves by the European Commission in their Horizon 2020 Data Pilot scheme, building on the work done by OpenAire and open access movement across Europe to open up the results of publicly funded research to the public. The goal of open science will bring about a greater more efficient, interconnected and robust system of science, producing new discoveries from data science and providing benefits through openness to other scientists, the public and business.

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[7] More information about the project is available here: http://nuffieldbioethics.org/project/research-culture/