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Interactive open access publishing and public peer review: The effectiveness of transparency and self-regulation in scientific quality assurance

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Abstract

The traditional forms of scientific publishing and peer review do not live up to the demands of efficient communication and quality assurance in today's highly diverse and rapidly evolving world of science. They need to be complemented by interactive and transparent forms of review, publication, and discussion that are open to the scientific community and to the public. The advantages of open access, public peer review and interactive discussion can be efficiently and flexibly combined with the strengths of traditional publishing and peer review. Since 2001 the benefits and viability of this approach are clearly demonstrated by the highly successful interactive open access journal *Atmospheric Chemistry and Physics* (ACP, www.atmos-chem-phys.net) and a growing number of sister journals launched by the publisher Copernicus (www.copernicus.org) and the European Geosciences Union (EGU, www.egu.eu). These journals are practicing a two-stage process of publication and peer review combined with interactive public discussion, which effectively resolves the dilemma between rapid scientific exchange and thorough quality assurance. The same or similar concepts have recently also been adopted in other disciplines, including the life sciences and economics. Note, however, that alternative approaches where interactive commenting and public discussion are not fully integrated with formal peer review by designated referees tend to be less successful. The principles, key aspects and achievements of interactive open access publishing (top quality and impact, efficient self-regulation and low rejection rates, little waste and low cost) are outlined and discussed. Further information is available on the internet: www.atmospheric-chemistry-and-physics.net/general_information/public_relations.html

Keywords

scientific evaluation, open peer review, collaborative peer review, open peer commentary

Introduction

The traditional ways of scientific publishing and peer review do not live up to the needs of efficient communication and quality assurance in today's highly diverse and rapidly developing world of science. Besides high profile cases of scientific fraud, science and society are facing a flood of carelessly prepared scientific papers that are locked away behind subscription barriers, dilute rather than enhance scientific knowledge, lead to a waste of resources and impede scientific and societal progress.[1–4]

Open access to scientific research publications is desirable for many educational, economic and scientific reasons, but one of its key advantages is often not recognized. Contrary to widespread misperceptions, open access is not a threat but an urgently needed opportunity for the improvement of scientific quality assurance:

1. Open access is fully compatible with traditional peer review, and beyond that it enables interactive and transparent forms of review and discussion open to all interested members of the

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scientific community and the public (public/collaborative/community peer review).
2. Open access gives reviewers more information to work with, i.e. it provides unlimited access to relevant publications across different scientific disciplines and communities.
3. Open access facilitates the development and implementation of new metrics for the impact and quality of scientific publications.

As detailed below, the effects and advantages of open access, public review and interactive discussion can be efficiently and flexibly combined with the strengths of traditional scientific publishing and peer review [1-4].

Interactive open access publishing

So far, the arguably most successful alternative to the closed peer review of traditional scientific journals is the 'interactive open access peer review' practiced by the journal *Atmospheric Chemistry and Physics* (*ACP*) (www.atmos-chem-phys.net) and a growing number of interactive open access sister journals [1-4].

As detailed below, *ACP* is by most, if not all, standards (editorial statistics, publication statistics, citation statistics, economic costs and sustainability) more successful than comparable scientific journals with traditional or alternative forms of peer review. The interactive open access peer review of *ACP* is based on a two-stage process of publication and peer review combined with interactive public discussion.

In the first stage, manuscripts that pass a rapid prescreening (access review) are immediately published as 'discussion papers' in the journal's discussion forum (*Atmospheric Chemistry and Physics Discussions, ACPD*). They are then subject to interactive public discussion for a period of eight weeks, during which the comments of designated referees, additional comments by other interested members of the scientific community, and the authors' replies are also published alongside the discussion paper. While referees can choose to sign their comments or remain anonymous, comments by other scientists (registered readers) are automatically signed. In the second stage, manuscript revision and peer review are completed in the same way as in traditional journals (with further rounds of review and revision where required) and, if accepted, final papers are published in the main journal. To provide a lasting record of review and to secure the authors' publication precedence, every discussion paper and interactive comment remains permanently archived and individually citable.

The interactive open access peer review and two-stage publication process of *ACP* effectively resolves the dilemma between rapid scientific exchange and thorough quality assurance, and it offers a win-win situation for all involved parties (authors, referees, editors, publishers, readers/scientific community). The primary positive effects and advantages compared to the traditional forms of publication with closed peer review are:

1. The discussion papers offer free speech and rapid dissemination of novel results and original opinions, without revisions that might delay or dilute innovation (authors' and readers' advantage).
2. The interactive peer review and public discussion offer direct feedback and public recognition for high-quality papers (authors' advantage); they prevent or minimize the opportunity for hidden obstruction and plagiarism (authors' advantage); they provide complete and citable documentation of critical comments, controversial arguments, scientific flaws and complementary information (referees' and readers' advantage); they reveal deficiencies and deter submissions of carelessly prepared manuscripts, thus helping to avoid/minimize the waste of time and effort for deficient submissions (referees', editors', publishers' and readers' advantage).
3. The final revised papers offer a maximum of scientific information density and quality assurance achieved by full peer review (with optional anonymity of referees) and revisions based on the referees' comments plus additional comments from other interested scientists (readers' advantage).

Readers who are primarily interested in the quintessence of manuscripts that have been fully peer reviewed and approved by referees and editors can simply focus on the final revised paper (or, indeed, its abstract) published in the journal and neglect the preceding discussion papers and interactive comments published in the discussion forum. Thus the two-stage publication process does not inflate the amount of time required to maintain an overview of final revised papers. On the other hand, readers who want to see original scientific manuscripts and messages before they are influenced by peer review and revision, and who want to follow the scientific discussion between authors, referees and other interested scientists, can browse the papers and interactive comments in the discussion forum.

The possibility of comparing a final revised paper with the preceding discussion paper and following the

interactive peer review and public discussion also facilitates the evaluation of individual publications for non-specialist readers and evaluators. The style and quality of interactive commenting and argumentation provide insights that go beyond, and complement, the information contained in the research article itself.

The two-stage publication process stimulates scientists to prove their competence via individual high-quality papers and their discussion, rather than just by pushing as many papers as possible through journals with closed peer review and no direct public feedback and recognition for their work. Authors have a much stronger incentive to maximize the quality of their manuscripts prior to submission for peer review and publication, since experimental weaknesses, erroneous interpretations, and relevant but unreferenced earlier studies are more likely to be detected and pointed out in the course of interactive peer review and discussion open to the public and all colleagues with related research interests.

Moreover, the transparent review process prevents authors from abusing the peer review process by delegating some of their own tasks and responsibilities to the referees during review and revision behind the scenes. Referees often make substantial contributions to the quality of scientific papers, but in traditional closed peer review their input rarely receives public recognition. The full credit for the quality of a paper published in a traditional journal generally goes to the authors, even when they have submitted a carelessly prepared manuscript that has taken a lot of time and effort on the part of the referees, editors and publishers to turn it into a good one. While peer review depends crucially on the availability and performance of referees, it has traditionally offered little reward for those providing careful and constructive reviews. In public review, however, referees' arguments are publicly heard and, if comments are openly signed, referees can also claim authorship for their contribution.

Note that most of the effects and advantages outlined above are not fully captured by alternative approaches where interactive commenting and public discussion occurs only after formal peer review and final publication of scientific papers or where the discussion paper and interactive comments are removed after publication of the final revised paper (see below).

Overall, the interactive open access publishing philosophy emphasizes the value of free speech and efficient public exchange and scrutiny of scientific results in line with the principles of critical rationalism. Accordingly, editors and referees are supposed to critically comment and evaluate manuscripts, to help authors improve their manuscripts, and to eliminate clearly deficient manuscripts. However, authors shall not be forced to adopt the editors' or referees' views and preferences. Instead, the readers shall be able to make up their own minds in view of the public review and discussion. In case of doubt, editorial decisions shall favor free speech of scientists, and in the end, scientific progress and history shall tell if – or to which degree – they were right.

Atmospheric Chemistry and Physics

The interactive open access journal *Atmospheric Chemistry and Physics* (*ACP*) (www.atmos-chem-phys.net), founded in 2001, demonstrates that interactive open access peer review enables much more efficient quality assurance than traditional closed peer review. *ACP* is run by the European Geosciences Union (EGU) (www.egu.eu), the open access publisher Copernicus (www.copernicus.org), and a globally distributed network of scientists (some 100 co-editors coordinated by an executive committee of five). Manuscripts are normally handled by an editor who is familiar with the specific subject area of the submitted work and independently guides the review process. Details about the largely automated handling and editor-assignment of submitted manuscripts are given on the journal website.

Currently *ACP* publishes some 600 papers per year (about 9,000 double-column print pages), which is comparable to the volume of traditional major journals in the fields of chemistry and physics (ISI Science Citation Index). On average, each paper receives four or five interactive comments, and about one in four papers receives a comment from the scientific community in addition to the comments from designated referees. In total, there is typically half a page of interactive comments per page of original discussion paper, i.e., the volume of interactive comments amount to as much as 50 percent of the volume of discussion papers. The interactive comments show the full spectrum of opinions in the scientific community, ranging from harsh criticism to open applause (sometimes for the same discussion paper), and they provide a wealth of additional information and evaluation that is available to everyone.

About three out of four referee comments are posted without the referee's name, showing that most referees in the scientific community of *ACP* prefer anonymity. There are, however, interesting differences between sub-disciplines: on average about 40 percent of theoreticians and computer modellers sign their referee comments, while only some 10 percent of the laboratory and field experimentalists do so.

It appears that modellers more often provide suggestions and ideas for which they like to claim authorship as a reward. The anonymous referee comments are generally also very constructive and substantial. The *ACP* editors do not actively moderate the public discussions but reserve the right to delete abusive or inappropriately worded comments. Out of the nearly 10,000 interactive comments that have been posted so far, only a handful were removed or replaced because of inappropriate wording, which demonstrates efficient self-regulation by transparency.

Some colleagues have expressed concerns that referees may loose their independence by having access to the comments from fellow referees and from the public. Indeed, referees with limited capacities occasionally seem to duplicate or refer to earlier comments without making up their own mind, but this is fairly easy to recognize and to take into account by editors and readers. Much more often, however, referees constructively build on or contradict earlier comments, which enhances the efficiency of review and discussion substantially. Overall, experience shows that the advantages of enabling direct interaction between referees clearly outweigh the disadvantages.

The average rate of public commenting in addition to the designated referees' and authors' comments specified above (about 25 percent) may appear low at first sight. It is, however, by an order of magnitude (factor ~ 10) higher than in journals with post-peer-review online commenting and in traditional journals without online commenting (about 1–2 percent) [4-5]. Discussion papers reporting controversial findings or innovations attract many interactive comments (up to 20 and more, see 'Most commented papers' in the *ACPD* online library: www.atmos-chem-phys-discuss.net/most_commented_papers.html). As expected, non-controversial papers usually elicit comments only from the designated referees. Why would scientists invest effort and time commenting on papers which they find interesting but non-controversial?

In most scientific disciplines and journals (certainly in the fields of physics, chemistry and biology with which the author is well acquainted) it is notoriously difficult to assign a couple of competent referees to every manuscript submitted for publication. In fact, this is the main bottleneck of peer review and scientific quality assurance, and most journal editors have to apply lots of manpower and electronic tools (invitation and reminder e-mails, etc.) to obtain a couple of referee comments per manuscript. Accordingly, the initiators and editors of *ACP* are quite satisfied with the overall number and volume of interactive comments. Higher rates of commenting were not expected and are not required to stimulate self-regulation mechanisms of scientific quality assurance[1].

The editorial and citation statistics of ACP clearly demonstrate that interactive open access peer review indeed facilitates and enhances scientific communication and quality assurance. The journal has relatively low rejection rates (some 10–20 percent as opposed to about 50–60 percent in comparable traditional journals [6]), but only a few years after its launch *ACP* had already achieved top reputation and visibility in the scientific community. Accordingly, it has the highest ISI journal impact factor (average number of citations per paper and year) in the discipline of Atmospheric Sciences (51 journals, including meteorology and climate science) and one of the highest across the fields of Geosciences (137 journals) and Environmental Sciences (160 journals). These numbers clearly confirm that anticipation of public peer review and discussion deters authors from submitting low quality manuscripts and, thus, relieves editors and referees from spending too much time on deficient submissions. This is particularly important, because refereeing capacities are the most limited resource in scientific publishing and quality assurance (www.atmospheric-chemistry-and-physics.net/acp_news_jcr_2007.pdf).

Since its launch in 2001, the number of articles published in *ACP* has increased rapidly (by about 20 percent per year), and the same is true for most interactive open access sister journals. The high and increasing rates of submission, publication and citation show that the scientific community values the open access, high quality, and interactive discussions of *ACP*. They confirm that there is a demand for improved scientific publishing and quality assurance, and that the interactive open access journal concept of *ACP* meets this demand.

Accordingly, the EGU and Copernicus have already launched a dozen interactive open access sister journals in the geosciences and related disciplines, and more are in the pipeline: *Atmospheric Measurement Techniques, Biogeosciences, Climate, Cryosphere, Drinking Water, Earth System Dynamics, Earth System Science Data, Environmental Resources, Geoscientific Model Development, Hydrology, Ocean Science, Solid Earth, Social Geography*, etc.

The interactive open peer review concept of *ACP* has also been adopted by the e-journal *Economics*, which is was launched in 2007 and involves some of the most prominent institutions and scientists in the field of economics (www.economics-ejournal.org). Alternative concepts of public peer review and interactive discussion are pursued by the open access

publications *JAMES* (http://adv-model-earth-syst.org, since 2008), *PLoS One* (www.plosone.org, since 2007), *Biology Direct* (www.biology-direct.com, since 2006), and *JIME* (http://www-jime.open.ac.uk, since 1996). Differences between the peer review concepts of these publications and *ACP* will be briefly discussed below.

Financing and sustainability of interactive open access publishing

ACP and its EGU/Copernicus sister journals prove not only the scientific but also the economic viability and sustainability of interactive open access peer review and two-stage publishing. The journals were launched and are operated by the independent scientific society EGU and by the small commercial enterprise Copernicus without public subsidies, private donations, or venture capital as involved in the start-up and operation of other successful open access publishers like PLoS and BioMed Central. After several years of operation, *ACP* and its sister journals have fully recovered the financial investments of EGU and Copernicus during the start-up phase, and they now generate a surplus which supports the start-up of new journals by the scientific society as well as a healthy growth of the commercial publisher generating over a dozen new jobs.

By developing and applying efficient software tools for the handling of manuscripts (submission, peer review and commenting, typesetting/production and distribution), and because minimal time and effort is wasted on carelessly prepared papers (high quality of submissions and low rejection rates as detailed above), Copernicus is able to produce top quality publications at comparatively low cost. The service charges for an average paper (about 10 pages in the final double column format) are about EUR 1000, covering editorial support, free use of colour figures and online supplementary materials (data, pictures, movies etc.), typesetting of both the discussion and the final version of the paper, archiving and distribution of papers and interactive comments (maintenance of websites and servers, electronic copies for open archives, paper copies for copyright libraries, etc.) and overheads. The service charges are adjusted to cover the full costs of publishing (including all services outlined above) and generate a modest surplus (about10%) that ensures sustainability of Copernicus, EGU, and their publications.

For each paper published in *ACP*, the service charges are levied from the authors or paid by their scientific institution. Recently, the Max Planck Society (MPG) in Germany and the Centre National de Recherche Scientifique (CNRS) in France have signed contracts with Copernicus for automated coverage of service charges incurred by their scientists. Other scientific institutions are likely to follow these examples, and many national and international research organizations and funding agencies are practising alternative ways of covering open access service charges for their scientists and projects, respectively. Like other open access publishers, Copernicus and EGU are ready to cover the costs for up to 10 percent of the papers published each year, if the authors are unable to pay the service charges (e.g. authors without institutional support or institutions from less developed countries). Currently, most papers published in *ACP* originate from Europe (about 60 percent) and North America (about 30 percent), but the proportion of papers originating from Russia, China, India and other countries is increasing.

The *ACP* open access publication service charges compare quite favorably with the charges levied by other comparable scientific journals and publications:

1. Other major open access publishers such as BioMed Central and the Public Library of Science (PLoS) typically charge more than EUR 1000 for traditional single-stage journal publications.
2. Traditional publishing groups like Springer charge up to USD 3000 for making individual publications in traditional subscription journals freely available online ('Open Choice'), i.e. they levy USD 3000 per online open access paper in addition to charging libraries and other subscribers for access to the journal in which it appears.
3. In the traditional scientific publishing business, where some journals not only limit access to subscribers or sell articles on a pay-per-view basis but also request additional publication charges from authors (e.g. hundreds of US dollars per page or color figure), the total turnover and public costs amount to several thousand US dollars per paper. The annual turnover of journal publishing in the sector of science, technology, and medicine (STM) amounts to around USD 7 billion per year, and some of the traditional publishers – led by Elsevier with a market share of about 30 percent – make operating profits of up to 30 percent and more. Note that a large proportion of the turnover and profit in STM publishing comes from packaging and selling publicly funded research results that are peer reviewed by publicly funded scientists in publicly funded institutions of education and research.

In view of these facts, *ACP* authors and the *ACP* scientific community have had little difficulty

accepting or paying average service charges of EUR 1000 per paper to make *ACP* and its sister journals sustainable. Overall, *ACP* and its interactive open access sister journals prove that top quality (interactive) open access publishing and peer review can be realized and sustained by scientific societies and (small) commercial publishers with tightly limited budgets and without public subsidies, private donations or venture capital.

Key features compared to alternative forms of peer review

To summarize, the key features of the *ACP* interactive open access peer review system that help ensure maximum efficiency of scientific exchange and quality assurance are:

1. Publication of discussion papers before full peer review and revision: free speech, rapid publication, and public accountability of authors for their original manuscript foster innovation and deter careless submissions.
2. Integration of public peer review and interactive discussion prior to final publication: attract more comments than post-peer-review commenting, enhance efficiency and transparency of quality assurance, maximize information density of final papers.
3. Optional anonymity for designated referees: enables critical comments and questions by referees who might be reluctant to risk appearing ignorant or disrespectful.
4. Archiving, public accessibility and citability of every discussion paper and interactive comment: ensure documentation of controversial scientific innovations or flaws, public recognition of commentators' contributions, and deterrence of careless submissions.

Combining all of the above features and effects is the basis for the great success of *ACP* and its sister journals. Missing out on one or more of these features is the main reason why most if not all alternative forms of peer review practised in other initiatives for improving scientific communication and quality assurance have been less successful (less commenting, lower impact/visibility, higher rejection rates, larger waste of refereeing capacities, etc.). For example, features 2 and 3 are not captured in most of the initiatives mentioned above.

Conclusions and outlook

ACP and its sister journals very clearly demonstrate that interactive open access peer review with a two-stage publication process and public discussion effectively resolves the dilemma between rapid scientific exchange and thorough quality assurance. They have proven that interactive open access peer review does foster scientific discussion, deter submission of sub-standard manuscripts, save refereeing capacities, and enhance information density in final papers.

Technically, interactive open access peer review can be easily integrated into new and existing scientific journals as well as large scale publishing systems and repositories (such as arXive.org) on the Internet – simply by adding an interactive discussion forum. Moreover, the basic concept of two-stage open access publishing with public peer review and interactive discussion can easily be adjusted to the different needs and capacities of different scientific communities by maintaining or abandoning referee anonymity, shortening or prolonging the discussion phase, adding post-peer-review commenting and rating tools for readers, making all steps/iterations of peer-review and revision transparent, adding further stages of publication for re-revised manuscripts, establishing feedback loops for editorial quality assurance, etc.

Besides communication and evaluation of scientific results, interactive open access publishing and peer review may also be applicable for efficient evaluation of scientific research proposals in the form of citable discussion papers. Again all involved parties could profit from public documentation, scrutiny and citability. At first sight, it might appear that the authors of a proposal would run a high risk of 'losing' innovative project ideas to the public, if their proposal were not immediately supported/funded. In practice, however, they would be better protected from (hidden) plagiarism and obstruction by competitors, and the citable publication would actually help them to claim authorship, precedence and recognition for their ideas. At the same time, the scientific community and society at large would profit from rapid dissemination of innovative ideas.

Overall, interactive open access publishing and peer review can strongly enhance scientific exchange and quality assurance and provide a basis for efficient use and augmentation of scientific knowledge in a global information commons [7]. Moreover, public review, discussion, and documentation of the scientific discourse can serve as an example for rational and transparent procedures of settling complex questions, problems, and disputes. It is a model for further development of the structures, mechanisms, and processes of communication and decision making in society and politics in line with the principles of critical rationalism [2-4].

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