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Open Peer Review: An Innovation in Scientific Publishing

peiling wang
University of Tennessee - Knoxville, peilingw@utk.edu

Manasa Rath
University of Tennessee, Knoxville

Michael Deike
University of Tennessee, Knoxville

Wu Qiang
University of Science and Technology, China

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P. Wang[1], M. Rath[1], M. Deike[1], Q. Wu[2]
[1]University of Tennessee at Knoxville, USA
[2]University of Science and Technology, China

Abstract
This research observes the emerging open peer review journals. In scientific publishing, transparency in peer review is a growing topic of interest for online journals. The traditional blind refereeing process has been criticized for lacking transparency. Although the idea of open peer review (OPR) has been explored since 1980s, it is only in this decade that OPR journals are born. Towards a more open publishing model, the peer review process--once accessible only to the editors and referees—is now available to public. The published article and its review history are being integrated into one entity; readers can submit or post comments to extend the peer process. This preliminary study observed four pioneer OPR journals representing pre-publication OPR and post-publication OPR. Data collection focuses on publication's lifecycle from its submission to peer approval. Preliminary results include comparisons of the level of openness and nature of interactions during refereeing process.
Keywords: transparency in peer review; open peer review; scholarly publishing; scientific publishing; post-publication peer review
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Contact: peilingw@utk.edu

1. Introduction

Scientific communication advances knowledge through the sharing of research findings in peer-reviewed publications. Editorial peer review can be traced back to more than 300 years (Weller, 2001). In its modern forms, a blind (single or double) pre-publication referee process is widely adopted by publishers and accepted by researchers. Peer review, although important, is understudied (Kassirer and Campion, 1994). Serious concerns about current peer review practices include: (1) peer review often fails to recognize high quality, even award-winning work (Michaels, 2006); (2) peer review does not weed out fraudulent or flawed research (Akst, 2012); (3) journal editors were found involving themselves in a 'peer review ring' scandal (Barbash, 2014); (4) journals don't have adequate systems to investigate misconduct or mistakes in scientific studies except for retracting published papers that are found to have serious mistakes (Naik, 2011). Smith (2006), a former editor, concludes: "peer review is a flawed process, full of easily identified defects with little evidence that it works. Nevertheless, it is likely to remain central to science and journals because there is no obvious alternative, and scientists and editors have a continuing belief in peer review. How odd that science should be rooted in belief." (p. 182). This belief is verified by a recent survey study: "peer review is still the most trustworthy characteristic of all." (Nicholas, et al., 2015)

The problems in scientific publishing, however, are real and serious in disciplines such as medicine. During one investigation, a single scientist's 172 papers out of 212 papers were found to be "bogus, 126 of which 'were totally fabricated.'" (Akst, 2012). Another instance showed a top ranked journal (Impact Factor 4.4) retracting 60 articles at once due to academic dishonesty (Barbash, 2014). Detecting research misconduct in the peer review process is difficult if not impossible ("Can Peer Review Police Fraud?" 2006) Currently, the magnitude of growth in "the size of science" is beyond that of big science predicted by Derek J. de Solla Price, a visionary in information science. At that time, the majority of scientists had only one or two publications in any research area (Price, 1963). Since 2001, the number of research papers published in research journals increased 44% while the number of retracted papers leapt more than 15-fold according to the data provided by Thomson Reuters (Naik, 2011). Thus questions are raised as to whether or not the traditional peer review process will be able to keep up with the growth in publication submissions. From a close look at the traditional blind review process, it is inevitable that the quality of the reviews may be compromised by the referees' knowledge, worldviews, time constraints, or fear of future reprisals (Lee, et. al, 2012); it is also possible that referees hold grudges (Even with blind peer review, referees can sometimes correctly infer the identity of the author or institution from content).

What might be the solution to these problems without throwing the baby out with the bathwater? Researchers are calling for innovations and modernization in the peer review process. Pöschl & Koop (2008) promotes the concept of collaborative peer review and interactive public discussion as effective

solutions to "the dilemma between rapid scientific exchanges and thorough quality assurance." (pp. 107) Soergel, Saunders, and McCallum (2013) argue that it is important to separate dissemination from evaluation to make scientific works public as soon as possible and to make the peer review process rapid, transparent, and participatory. They built a prototype system (OpenReview.net), which was pilot tested at the International Conference on Learning Representations 2013 held at Scottsdale, Arizona, USA to handle submission, open reviewing, and public discussion. They conducted a post conference survey of participants and found: the open model increased the quality of the papers, public visibility of reviews made reviewers more constructive and diplomatic, the decision process was perceived as fair in the open reviewing model, author's anxiety about open reviewing was reduced as a result of the experience, and diverse preferences were expressed on if the reviewers should remain anonymous. Ideally, the open peer review (OPR) process can foment interactions in the scientific community by transforming the peer review process into a more diplomatic conversation. To accelerate the dissemination of scientific findings is of critical importance in medicine and related fields.

The OPR model in scientific publishing is still in its pioneering stage, and the majority of the researchers either is not aware of the new model or has doubts on its validity and benefits. Will the innovation be adopted to bring a paradigm shift to modernize scientific communication? The purpose of this research is two-fold: (1) to observe current OPR journals to understand its current state of the art; (2) to propose an agenda for systematical research on OPR's future scientific publishing.

1.1 The OPR Journals

Ford (2013) reviewed literature and identified some OPR's characteristics: reviewers signing identities, pre-publication review, post-publication review, crowd-sourced review, and transparent review. The pioneer journals currently in practice show diverse policies and processes in handling peer review: pre-publication vs. post-publication, anonymous vs. signed review reports, process mediated by an editor, publishing review history, sharing data mandate, allowing reader comments with or without mediation. Four OPR journals, born in 2012, are chosen for this study (data accurate on September 8, 2015):

- PeerJ is a pre-publication OPR journal. Since 2013, it has published 1243 articles coving biology, medicine and computer science.
- eLife is a pre-publication OPR journal. Since 2012, it has published 1673 articles in life sciences and biomedicine. (Of 1673 articles, 1191 are research articles.)
- GigaScience is a pre-publication OPR journal that publishes large–scale data research articles and host these data. Since 2012, it has published 23 big data research articles in biology and biomedicine.
- F1000Research is a post-publication OPR and fully transparent peer review platform. Since 2012, it has published 951 articles, of which 337 are research articles. F1000Research covers medicine and biology.

1.2 Research Questions

Research is needed to understand the nature of OPR journals. In traditional blind peer review systems, confidentiality made it impossible to observe the peer review processes except for the journal editors who alone have access to the review reports and reviewer's identity. As an adventure in scientific publishing, the OPR journals/platforms provide access to review history, which opens the opportunity to study the peer review process and those involved as author, reviewer, or reader. In this paper, we investigate:

- To what extent do the open review systems speed up scientific publishing?
- What are the characteristics of OPR journals and their research articles?
- What are the advantages and concerns of OPR models in current practices?

2. Research Method

2.1 Conceptualization and Measurements

Open peer review vs. open access. In the open science movement, these two terms are often intertwined although they focus on different issues. *Open access* (OA) seeks to make peer-reviewed journal articles freely accessible through the Gold OA model (free access to articles published in the OA journals) or the Green OA model (free access to articles self-archived by the authors in repositories). *Open peer review* (OPR), however, seeks to make the traditional blind peer review process transparent through open processes. Six elements of *openness* feature the peer review process: (1) research data deposition, (2) editor involvement, (3) identities of referees, (4) availability of referee reports, (5) author's responses, and

(6) readers' participation. A fully open OPR journal will publish authentic peer review history alongside the published article as well as reader comments. In this scenario, the article, its revisions, its history of referee process, and reader comments are all an integral part of the single intellectual entity.

Publication timelag vs. *indexation time.* Publication timelag is the total days from submission to publication calculated by adding the *acceptance time* (from submission to acceptance) and the *publication time* (from acceptance to in-print). Indexation time is a new measurement for the post-publication OPR model because the traditional measures, acceptance time and publication time, are not applicable. For post-publication OPR journals, a policy is needed to specify the criteria for indexing a published article. F1000Research sets the threshold for indexation as follows: (1) the article is approved by two referees; (2) the article is approved by one referee plus approved with reservation by two referees. The *indexation time* is the days between the publication date and the indexing threshold date (Table 1).

2.2 Data

	F1000Research	PeerJ	eLife	GigaScience
Timelag (Median)	Publication: ~7 days; Indexation: 35 ~ 69 days	Acceptance: 74 days; Publication: 22 days	Acceptance: 90 days; Publication: 29 days	Acceptance: 102 days; Publication: 22 days
Referee anonymity	Non-anonymous	Referee can opt	Editor named; referee anonymous	Will honor referee's request for anonymity
Publish referee history	Alongside immediately	Author's decision	Majority of articles (View in eLife Lens)	Complete pre-publication history
What is included in referee history?	Original reports	Editor's decision letter & individual review reports	A decision letter (may include reviewers' comments)	Editor's comments, individual review reports
Number of review reports per article	2 to 7	2 to 3	A decision letter if history published	2 – 6
Author Response	Alongside immediately	Yes, only if history is published	Yes along with the decision letter	In history
Reader comments	Alongside immediately	By registered users	Moderated by editor	BioMed Central registered users
Original vs. Revisions	All versions published	All versions only if history published	Accepted version	Accepted version
Data/software deposition	Required	Required	Required	Required
Article level metrics	View, download citations, AltMetrics	Download, social media article	Saved, citations and social media	Access, citations, AltMetric, awards
Example	http://f1000research.com/articles/4-32/v2	https://peerj.com/articles/1238	http://elifesciences.org/content/3/e01808	http://www.gigasciencejournal.com/content/4/1/37

Table 1. Openness comparisons across the four OPR journals

In this paper, data sources include F1000Research, PeerJ, eLife, and GigaScience (Table 1). Data from F1000Research are the focus because the journal adopts a fully open and transparent peer review process. Timelag data are from Himmelstein (2015). Submissions to F1000Research are published typically in 7 days after basic checking on language, description of methods, possible plagiarism, ethical compliances and data deposition requirements. Indexing by Scopus and PubMed is an important milestone representing the article's approvals by at least two reviewers (see 2.1). The authors may publish revised versions. All versions of the article are accessible as a single Web entity. The F1000Research dataset, harvested on March 20, 2015, includes 753 published articles, of which 229 were indexed research articles or observational articles. This paper focuses on the 215 indexed research articles. Data were cleaned and loaded to a database. The records include timestamps of the peer review process and article level metrics (downloads & altmetrics). The dataset also includes non-structured texts: referee reports, author responses, and reader comments. This text corpus contains 996 files.

3. Results

Of the 215 indexed articles, 58% were approved in their first version and indexed. For the articles approved in their original submissions, 21% published a revised version. Only 37 authors (4%) authored or co-authored more than one article. One group of 3 authors published 4 articles within 8 months. In terms of co-authorship, one article has a max number of 33 co-authors while 90% of articles have between 1 and 7 authors. Six referees also authored research articles in F1000Research. These articles were reviewed by 2 to 7 referees.

3.1 Indexation Time vs. Publication Timelag

Medians instead of means are used to measure publication timelag. Himmelstein (2015) used medians to measure acceptance time and publication time of 3746 journals considering that data did not fit normal distributions. Our comparisons of medians with means for *indexation* show a similar effect. For example, the *indexation* median for F1000Research articles approved without a revision is 35 days but the *indexation* mean is 75 days (SD 103; range: 1 to 565 days). The *indexation* median for the articles approved after revision is 69 days but the mean is 104 days (SD 107; range: 2 to 559 days). The publication timelags for eLife from its Website, and PeerJ and GigaScience are from Himmelstein (2015): PeerJ, 96 days; eLife, 119 days, and GigaScience 124 days (Table 1).

3.2 Characterizing Indexed F1000 Research Articles

The country of origins of authors and referees. A total of 929 authors from 50 countries published the 215 indexed research articles. There are 45 articles by authors from a single country (21%
), 122 articles by authors from 2 countries (57%), 46 articles by authors from 3 countries (21%), 2 articles by authors from 4 countries (1%). The top 5 countries of author's origin include 346 US authors (37%) listed in 103 articles (50%), 95 UK authors (10%) listed in 31 articles (14%), 54 Australia authors (6%) listed in 22 articles (10%), 45 Germany authors (5%) listed in 17 articles (8%), 36 Canada authors (4%) listed in 13 articles (6%). A total of 544 referees from 46 countries reviewed the 215 indexed research articles, of which three referees reviewed three articles and 10 reviewed 2 articles. The top 5 countries of referee's origin include 215 US referees (40%) reviewed 140 articles (65%), 59 UK referees (11%) reviewed 46 articles (21%), 33 Canada referees (6%) reviewed 34 articles (16%), 30 Australia referees (6%) reviewed 27 articles (13%), and 29 Germany referees (5%) reviewed 25 articles (12%).

Where else do F1000Research authors publish? On July 20, 2015, searches of the authors of the top downloaded F1000Research articles in Web of Science retrieved 166 journal articles. These articles were published in reputable journals such as Science, Nature, and Annual Review of Entomology. The other journals in which F1000Research authors have published show a highest impact factor of 42.3 and a mean impact factor of 9.7. Searches of these authors in Scopus found 96 authors. Their mean H-index was 11 and the highest H-index 97.

Article Level Metrics. The top 10 accessed articles in F1000Research range in a descending order from 4,647 to 795 downloads as of July 16, 2015. Recently, F1000Research introduced additional article level metrics, such as citation data from Scopus, and AltMetrics data. It is too soon to compare these metrics since the first research article was published on July 16, 2012.

3.3 Advantages and Concerns of OPR

For researchers, the OPR journals offer a new level of transparency through openness. Not only will the authors have the opportunity to disseminate findings by publishing first, but they also will have the opportunity to respond to criticisms openly and their work commented by readers. All of the interactions become a part of the published article, so that its validity can be judged and improved by the scientific community at large as the article lives on. In one case, a referee's report was greyed out to note a potential conflict of interest.

Publishing readers' comments alongside of the article is supported by today's Web technology. The OPR journals in general allow such participations either moderated (eLife) or unmoderated (F1000Research). Allowing readers to contribute to the evaluation of the published scientific work signifies another level of openness. For example, an article was approved by three referees in January 2013. Ten months later, a reader, name identified, made comments for objection, arguing "… The claims and assertions made in this article are not only flawed but they represent dangerous pseudoscience. …" The author posted a detailed response 6 months later. What impact might such debate bring? We compared access data: on July 20, 2015, this article was ranked as top 3 (1,068 downloads); on December 10, 2015, this article showed a notable increase in downloads (26,127 downloads). In contrast,

smaller increases were observed for the July top 1 article (then 4,647 to now 4,707 downloads; see also 3.2 *Article Level Metrics*) and for the top 2 article (then 1,173 to now 1,272 downloads).

Is there potential influence if later reviewers are able to see others' reports prior to their own reviews? In the blind peer review model, a submission is reviewed independently by referees. In a fully OPR system, however, this could be a concern. We analyzed the agreement of referees' rating sequentially: in 69.5% of the cases the recommendations are the same; in 15.7% of the cases, the later referees are less favorable; in 14.8% of the cases, the later referee gave better recommendation. Further analysis of the corpus may provide some evidence of whether or not the early recommendations influenced later recommendations. In eLife Science's review process, editor may hold online discussion (http://elifesciences.org/about). Majority of the eLife research articles seem to have decision letter and author response alongside of the article if there is a link to "View in eLife Lens" or "Jump to:" sidebar.

The major issue is the lack of standards or de facto standards for OPR implementations. Each journal has its own policy and procedure for accessibility, openness, anonymity, and functionality. Structures of review reports vary across the four OPR journals. If the structure of the review report is not defined, referees tend to write reports based on their own comfortable norms. On the spectrum of openness based on policies, F1000Research publishes full peer review reports immediately, while eLife and PeerJ allow referees to opt out of identifying their names, and authors to opt out of reproducing review reports. Therefore, some articles are published without a review history; some articles with review reports by Reviewer 1, Reviewer 2, etc. GigaScience publishes pre-publication history including reviews and revisions, but will honor anonymity if reviewers so request. About 70% research papers in PeerJ published a review history alongside the article. Given the option to maintain anonymity, 85% of articles in the PeerJ with a review history had at least one reviewer unidentified.

All the OPR journals we examined lack advanced search features beyond providing keyword search and a few predefined filters; vary in interactions, page layout, and metrics. System features are added or removed without documentation. For example, F1000Research no longer display an article's timestamp for indexing, making *indexation* a hidden concept. These issues hinder system's usefulness and usability.

4 Discussion & Conclusions

The answer to the first research question is obvious that F1000Research measured by its median *indexation* time (35 days without revisions or 69 days with revisions; should add 7 days for submission to publication) presents the fastest review process as compared to the three pre-publication OPR journals measured by *publication* timelag (96 days for PeerJ, 111 days for eLife, and 124 days for GigaScience, respectively). As a post-publication OPR journal, F1000Research does not have editors to mediate the process. eLife, on the other hand, holds synchronous peer review meetings for some submissions, adding the need of scheduling. Once accepted, eLife publishes articles much faster than PeerJ or GigaScience (Table 1; Himmelstein, 2015). Another difference is that PeerJ publishes preprints; a preprint and its published article were assigned different DOIs but hyperlinked from one another.

For the second research question, we observed the characteristics of the four OPR journals to compare openness in peer review. All OPR journals acknowledge the benefits of providing review histories, but the policies vary in specific elements (Table 1). The level of openness is likely affected by the journal's policy, referee's willingness to sign identity, and/or the author's perception of the benefits in sharing review history. The more transparent an OPR journal is, the more likely its *authors* care more about the quality of the initial submissions. F1000Research represents the most open and transparent OPR model of the four journals; its research articles had a lower revision rate and more than half of them were approved for indexing without revisions. Authors do respond well to reviewers' comments. All articles have author responses. In many cases, authors made revisions even though the articles were already approved (21% of approved articles published a revision). The more transparent an OPR journal is, the more likely its *referees* make more substantial efforts in reviewing the articles. Further analysis of the referee reports should provide a better understanding of the referee's engagement.

Allowing readers to participate in evaluation and commenting is another distinctive feature of the OPR journals. Readers not only benefit from accessing the peer review reports but also can provide independent evaluations of the published scientific work.

For the third research question, the major advantages of fully OPR journal being faster in disseminating findings; encouraging better submission quality, which is also observed by Soergel, Saunders, & McCallum (2013); allowing participation of scientific community in gauging quality and validity of the published scientific work. The purpose of openness to achieve fairness and transparency in publishing research findings is obvious in that both authors and referees are held accountable for their

participations in the peer review process. Transparency is enhanced by post-publication OPR without editors mediating the process and requiring signed identity. Quality of the original submissions in post-publication OPR is likely to be higher than blind-reviewed journals as indicated by the higher rate of approvals of the first version. However, the higher rate of approvals of the original submissions may also indicate that the OPR referees tend to give a positive recommendation but will supplement critical comments in reports. In addition, OPR journals also provide scientists a new way of learning about scholarly publishing. Budding authors and referees are likely to benefit most from peer review history.

The major issues need to be addressed include standards in policy and system design. The OPR community needs to come together to establish and enforce standards. The lack of moderation in fully OPR models also raises concerns as to the degree of consistency across reviewers. Do they review at the same level of detail or rigor? How should reader comments be monitored? Can OPR journals draw on experiences from other online communities?

As an information retrieval system, the platforms must improve functionalities and ensure stability of features. Researchers need to examine various platforms under well thought out framework to identify best practice. Designers of the OPR systems must establish standards.

The success of the OPR model will depend on its adoption by a critical mass of active researchers who publish findings. Since its inception in July 2012, 1,477 scientists have published or reviewed research articles in F1000Research; the majority of them are US or UK scientists. By publishing or reviewing F1000Research research articles, these scientists endorse the fully open and transparent OPR model.

Further research. As an innovation for scientific publishing, OPR models are still in a developmental stage with a future yet in the making. To advance research in this area, further studies need to identify appropriate frameworks and research agenda.

To extend the preliminary results in this paper, analysis of the corpus of F1000Research review transactions is in progress. The interactions between the authors and referees can provide insight into collaborative peer review (Pöschl & Koop, 2008; Wang, 2015). Corpora of review transactions in PeerJ and eLife will be collected to compare with F1000Research.

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