The Issues of Open Peer Review and Their Envisioned Solutions using Computer Science Related Technologies

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***Abstract*—A major change in peer review was driven by the Open Science movement. As a creation by Open Science, open peer review is characterized by open identities, open reports, open participation, open interaction, open preview manuscripts, open commenting, and open platforms. In this paper we analyze the two experiments on open peer review done by *Nature* in 2006 and *Nature Communication* in 2016. Judging from the results, we identified many issues in open peer review in practice. They are related to the psychological stress, the thinking pattern, disciplinary differences, the absence of an incentive mechanism, the concern for academic priority, the influence of environmental factor, and the quality of comments. To address the issues, we give our visions on building the corresponding solutions using the Computer Science related technologies such as Artificial Intelligence, Blockchain, and Social Networks. It is expected that with the rapid developments in technology and the quickly-growing Open Science movement in social environments, open peer review will certainly bloom when the issues are successfully addressed.**

Keywords—Open Peer Review, Open Science, Blockchain, Artificial Intelligence, Social Networks

I. INTRODUCTION

Peer review, as a method used by academic journals to control the qualities of academic publications, is considered as an important part of an academic publishing process. Though it plays a key role in the process, it still has defects: it prohibits the developments of innovative but sometimes controversial projects; it places an excessive emphasis on the fame of an author; it is not conducive to the evaluations of interdisciplinary and frontier studies; it lacks a proper supervision and feedback mechanism; it impedes creativity [2].

Addressing the above problems, "open peer review" was proposed in Armstrong's paper, *Peer-Review Practices of Psychological Journals: The Fate of Published Articles*, in 1982 [10]. Open peer review is an improved peer review method, and it conforms to the "openness" goal of open science. Open peer review is characterized by open identities, open reports, open participation, open interaction, open preview manuscripts, open commenting, and open platforms [11].

The various research developments on open peer review has been going on for 30 years. From the 80's to 90's, the research focus was on the weakness of peer review and the necessity of building an "open" mechanism for peer review. For example, the identities of author and reviewer are disclosed, against the practice in the traditional double-blinded peer review practice, to guarantee the fairness of review. When it came to the twenty-first century, the publication of *Budapest Open Access Initiative* marked the birth of "open science". Open peer review was proposed as a part of the open science movement. Many researchers did plenty of related experiments to verify the possibility for applying an open peer review mechanism to scientific systems. Moreover, people's positive attitudes to and acceptances of such a new peer review mechanism also attracted their attentions.

Peer review is a vital part of an academic publishing process. As a world-famous academic journal, *Nature* has spent a lot of work to improve and reform its peer review process to make it more objective, open, and fair, and its experiments on open peer review were impressing. In 2006 and 2016, two relevant open peer review experiments were performed by *Nature* and *Nature Communications* respectively. By the analysis on these two experiments, many issues for open peer review in practice can be found in the contexts of the related social and technological environments. We analyze the issues and provide suggestions on how to effectively address them using the Computer Science related technologies such as Artificial Intelligence, Blockchain, and Social Networks.

The rest of the paper is organized as follows. Section 2 introduces the two open peer review experiments by *Nature* in 2006 and *Nature Communications* in 2016. Section 3 provides our analysis on the two experiments. Section 4 provides our thoughts on how to solve the found issues of open peer review in practice from the experiments. It also gives our suggestions on building the corresponding solutions using CS related technologies such as AI, Blockchain, and Social Networks. Finally, Section 5 concludes this paper.

II. The Two Open Peer Review Experiments

A. The Open Peer Review Experiment by Nature in 2006

Before the experiment, *Nature* launched a survey on authors' attitudes towards open peer review to ensure that the experiment would have enough supports from its authors in order for it to proceed. Afterwards, *Nature* sent a message to notify all its registrants and readers about the experiment. Meanwhile, its editors also contacted directly the researchers who might be interested in the experiment. Finally, the experiment was highlighted on *Nature's* home page to remind readers of the ongoing experiment to attract more people to participate in the experiment.

The entire experiment lasted for four months from Jun 1st to Sep 30th, 2006, during which *Nature* accepted 1369 papers for peer review. Almost 5 percent of the authors (71) were willing to participate in open peer review. Their papers would go through both an open peer review process and a traditional peer review process. The results would then be kept and updated on an open sever by editors along with the public comments gathered on them. The duration time of the open peer review process is consistent with that of the traditional peer review process. There were 15 different subjects for those papers, including Astronomy, Cell Biology, Climate, and so on. Though the experiment received much attention with the volume of online traffic reaching 5600 page visits per week, the number of public comments gathered turned to be very low. During the experiment, there were totally 92 scientific comments that were distributed among 38 open peer-reviewed papers. Specifically, 8 papers received 49 comments, and the rest of the comments were evenly distributed for the rest of the papers. The submission time of a paper was a factor influencing its number of comments received [3].

B. The Experiment by Nature Communications in 2016

Ten years after *Nature's* open peer review experiment, *Nature Communications* initiated its peer review experiment named "Transparent Peer Review" in January 2016. The objective of this experiment is to "openize" the peer review reports that had been traditionally hidden in the publishing process in the past, testing the authors' rate of acceptance on "openizing" their peer review files. The authors were also given the right to decide whether or not to make open their files. The reviewers could decide whether or not to review a paper, but they did not have the right to deny the publication of their related review files (but they were offered an option to remain anonymous). If a reviewer wanted to sign his review files, he /she could write on the paper directly. 787 of the qualifying papers was published during the year, and about 60% of the authors voluntarily chose to publish the peer review history files of their paper. In research areas/disciplines where open peer review was more common, a higher percentage of the reviewers signed their reports, and the numbers of authors opt-in were also very strong. This was not the case for the other and comparably larger number of areas where the traditional non-open peer review method(s) played a dominant role.

III. The Analysis on The Two Experiments

Though a more open peer review process is the common subject of these experiments, they differed on the level of openness, applications, and results. The details can be found in Table 1. Because of the ambiguous boundary of open peer review, various definitions exist in the literature. However, what *Nature* has done provides a more practical understanding of it when compared with those done by others. The common and particular issues found from the two experiments were given as follows.

TABLE I. Comparison of the Two Experiments

Journal	Nature	Nature Communications
Time	2006	2016
Type	Open peer review	Transparent peer review
Duration	Four months	A year
Qualifying Paper	1369	787
Opt-in rate	5%	60%
Object	The public/Peer reviewers	Peer reviewers
Result	Comment/Report	Report
Signature	Compulsory	Voluntary
Storage	Public severs	Traditional submitting system

A. The Psychological Stress

Even though there has never been a clear definition of open peer review, open identity is commonly accepted as the most distinctive feature of open peer review. The psychology states of authors and reviewers are at the basis of the entire experiments. Open identity played as an important psychological factor deciding the involvement of peer reviewers and authors, and specifically whether a signature is compulsory or not played an important role in the process.

For the reviewers, open identity is the most influential psychological factor affecting a potential review expert's decision on whether or not to be involved in the process. If an author and a reviewer are familiar with each other, the reviewer may give up his reviewer role to avoid any suspicion on nepotism. Especially, when the review result is positive in an open environment, the situation may be more complicated. Conversely, the reviewer may also quit because of his sentimental feelings for the author. Concerned with competing interests or with the author's fame, a review expert will probably refuse to review the article. Some other reviewers may worry about the possible retributions as a result of giving a negative review. A review report, filled with the reviewers' information and achievements, is to be published in an open peer review process, which may limit the scale of involvements by potential reviewers.

For the opposite part, the author, he/she would need courage and the psychological competence to make open his paper and to accept criticism from the public. When receiving comments on a paper with an open identity, the author may pay more attention to the opinions received. If the opinions are positive, there will not be too many troubles for the author. However, on receiving a negative review, the author will be under pressure, concerned with the possible damage to his fame, which can harm a young researcher's enthusiasm on

doing research. Therefore, it requires that the author should not only be confident with his research result but also have a sound psychological competence.

B. Thinking Pattern

The selection of reviewers is done by an editor, after a paper is submitted, according to his/her expertises in a traditional peer review process, and this inertia has shaped the reviewers into a passive thinking pattern. They are more used to performing a review by invitation rather than by taking the initiative to review themselves. In the 2006 experiment, though some editors did contact some interested reviewers for reviewing papers, most of the reviewing and commenting opportunities were set on a voluntary basis, which appeared strange to many traditional peer reviewers. The 2016 experiment was editor-oriented as well, and what the reviewers needed to do were to respond to the invitations they received.

C. Displinary Differences

Differences among disciplines also impact their academic publicities. A more open, more effective, and fairer communication between researchers is actively pursued in some areas. For example, physics scientists introduced *arXiv* preprint system to promote academic communication in the 90's. 11 Of the 71 open papers submitted in the 2006 experiment were Physics paper. A possible reason for this was that the preprint shares some similarities with open peer review to some extent, and as a result, compared with the scientists from the other areas, the physicists were more willing to participate in open peer review, many features of which were already familiar to them. The 2016 experiment was still affected by disciplinary differences. Though the opt-in rate was around 60% on average, the highest rating discipline was 30% higher than the lowest one.

D. The Concern for Academic Priority

The papers submitted in the 2006 experiment were reviewed by the editors first and then achieved on an open (public) sever to receive public comments without addressing potential plagiarism problems. Some of the authors were concerned that, once achieved publicly, their unpublished papers might be plagiarized during public commenting period, losing their academic priorities. Academic priority is the academic confirmation on and acknowledgement to a scientist's work, signifying the developmental breakthrough of a related discipline or some of its sub areas, which is regarded as an award to a scientist's creative contribution and also as an incentive to push forward scientific developments. The lack of protection on academic priority during the experiment dampened the authors' enthusiasms. For the 2016 experiment, the submission and review of a paper were done in a revised system that could effectively protect the paper from plagiarism.

E. The Influence of Enviromental Factor

Nature's open peer review experiment was carried out in 2006 when *Facebook* had just been established for two year and *Twitter* would start in the July. At that time, as the participants in the experiment, the registered users and readers were not used to publicly expressing themselves on the internet like people do today. The email service in the *Nature*'s experiment was less convenient and responsive compared with today's social networks. When an editor was choosing a reviewer, he/she needed to rely on his/her own personal network, which limited the selections of potential reviewers who might want to give comments or produces a review report. With the fast developments of social networks during the last decade, interpersonal relationships have been becoming less and less necessary for such means, as business social networks like *LinkedIn* can help an editor find an appropriate reviewer effectively and quickly.

F. The Absence of an Incentive Mechanism

Despite that it was claimed "publication of reviewer reports provides more credits to the work of our reviewers" in the 2016 experiment, there was still an absence of an appropriate incentive mechanism in both experiments. Because peer review is a non-profit oriented activity, peer reviewers don't get many physical rewards. For researchers, being a journal's peer reviewer is an honor, and performing a review is a voluntary work. To some extent, it is an academic acknowledgement to what a scientist has achieved in the related field. In an open peer review process, everyone can express their opinions and has a chance to be a reviewer, which may render the original and traditional reviewers to lose their senses of honor. This could be a reason why a number of experts refused to participate in the experiment. Though the reviewers' reports were published in the 2016 experiment, the reviewer anonymity prevented work authentication, because it was hard to match a report with a reviewer.

As a reviewer's work, a peer review report is full of his/her wisdom and expertise, which probably drives the progress of relevant research or inspires other potential researches. The submissions to high-quality journals like *Nature* often require reviewers to contribute more time and energy. *Nature*'s data traffic showed that the experiment interested some potential reviewers a lot, but the interest could hardly be transformed into a desire to review without a reasonable reward as a return. Besides material awards like a discount for publishing, job promotion, and funding for research, it is more important that a reviewer's report gets better acknowledged by academia so that the reviewer can accumulated more honor and fame [7].

G. The Quality of Comment

It was not only the low number of comments that affected *Nature*'s experiment but also the qualities of them. After the experiment, it could be found that though there were no inappropriate or disordered comments, the editors' expectations of high academic qualities on comments were never met as reflected in the editors' feedbacks. Only a few comments could reach the quality level of comments received in the traditional way. In addition, the comments' editorial values were more than their technical value, as most of them were general comments, such as "good" or "nice work". At the initial stage of the experiment, the editors had problems in setting a proper way for commenting. The reviewers were only provided with a general "comment" section only. Creativity, pragmatic value, and feasibility are three common criteria for quality of comment in the traditional way. Their comments usually have a fixed format and higher qualities than the normal public comments received during the

experiment. So, there should be a proper and formatted way for experts to provide their professional opinions [1].

IV. Thoughts on Solutions to the Issues in Open Peer Review Using the CS-Related Technologies

A. Building an Overall Open Peer Review Environment (Solution) Using Social Networks

As a result of the rapid developments of computer and internet technologies, open science now consists of open source, open access, open data, open science policies, intellectual rights, and open peer review. The rapid growths of social networks also affect open peer review greatly: besides proving the public with a new way to communicate on the internet, it is more important that social network has changed people's ways to express themselves. Compared with the people in the year when *Nature*'s experiment was launched, people nowadays are more willing to give their comments and opinions on social medias. Academic social networks like *RearchGate*, *Academia.edu*, and *Mendeley* gradually become the places where scholars download and share papers, express their academic opinions, cooperate with each other, which can be a proper technical solution to support and sustain open peer review [9].

B. Adpoting a Blockchain-based Solution to the Psychological Stress

Blockchain technology can be adopted to solve the problem that many experts refuse to participate in open peer review for worries on their disclosed identities [13]. In the narrow sense, a blockchain is a data chain in temporal order. It is a decentralized and distributed ledger with a cryptographic function to ensure the immutability of its data on the chain, so it can store simple, sequential, and verifiable data safely. Blockchain has four main characters: decentralization, consensus mechanism, stable temporal sequence, and reliable data relationship [14]. The problems open peer review is facing can probably be solved by utilizing these four characters, including the huge amount of data, complex interaction type, privacy protection, publishing of data, impact assessment, and the reproductivity of research results. A reviewer's privacy can be protected by blockchain's cryptographic function. Experts can go through reviewing without even disclosing their identities, but they can still be supervised, which deals effectively with the reviewers' psychology stress caused by disclosed identities.

Besides advertising open peer review to the public, famous experts in various domains or those supporting open peer review should be invited to endorse open peer review by Pygmalion effect to promotes the public's acceptances of open peer review.

C. Confirmation of Academic Priority by Blockchain

A straightforward solution to academic priority is the use of preprint: to put the papers that will through an open peer review mechanism into a preprint system in advance to confirm academic priority [6]. A second solution is post-publication peer review. It can be known from its name that the system adapts the pattern of publishing first and then reviewing, which is often used in some open peer review practices to confirm academic priority. A third one is enabled by applying the blockchain technology. Papers are put onto a blockchain to get a unique timestamp to confirm academic priority, which produces similar effects like those that a preprint system does. The difference of these two solutions will be discussed in another paper by us.

D. Constructing an Incentive Mechanism using Blockchain Tokens

Academic Incentive. The lack of an academic incentive can be solved by publishing reviewers' review reports alongside the authors' papers. Reviewers' reports are only allowed to be shown between editors and authors in traditional peer review. But in an open peer review, the reports are tied to the papers in a formal way. A relevant DOI number can be assigned to a review report and it can help researchers know about the reviewer's opinions and contributions, and they can also cite the comments. Connecting the DOI of a review report to his/her ORCID and the reviewer's resume to promote academic acknowledgements to his/her review works can also be used for the purposes like promotion and funding application [12]. Another benefit by doing it is the separation of experts' comments and the public ones in a formalized review report to solve the imbalance between the qualities of comments: it not only guarantees the public's participation in academic communication but also the rigor of science.

ACP and *Publons*, these two open access platforms have done similar works on providing academic incentives. *ACP* divides peer review into two stages. The first stage is the submission of a paper's simple peer review reports to an open platform, attracting and inviting relevant experts for discussions and commenting, which will be published on *ACPD*. Then the paper will be published on *ACP*. *ACP* and *ACPD* have two different ISSN numbers to save and cite on. *Publons* provides a service to assess a reviewer's academic contributions, which has been credited by academia [5]. According to a relevant survey, there have been over 600 thousand assessment reports for 110 thousand reviewers on the platform till 2017. Many institutions like *Harvard University* have accepted their reports as a means to access their scholars.

Material Incentive. Apart from the academic incentive, material incentive can also be provided by blockchain's token reacted functions to improve an expert's wiliness to participate in open peer review. Mechael Spearpoint proposes an open peer review incentive system in has paper *A Proposed Currency System for Academic Peer Review Payments Using the Blockchain Technology* [8]. Certainly, there is still an argument over the management of material incentive in terms of tokens for academic purposes. For instance, whether these science tokens should be pegged to another currency or limited among academic journals. Recently, *Digital Science*, a research-technology firm in London turned the idea into practice, launching the *Blockchain for Peer Review* project in May, 2018. Other research companies and/or organizations like *Springer*, *Katalysis*, and *Taylor & Francis* joined the project. *Scienceroot* are utilizing blockchain's token-based incentive mechanism to push the virtuous circle of the entire open peer review mechanism.

E. Susutaining the Model of Open Peer Commentting by Social Networks

Open peer review and peer commenting are two related but different processes. The purpose of peer review is to point out the defects in a paper using review experts' expertises. The quality of a paper is improved through the academic communications between reviewer(s) and author(s). As a result, a signed review report should be the standard result of peer review.

Open peer commenting is for both the public and the experts from other domains. The expectation is that they can propose new ideas and/or conduct simple academic communications during an open peer review commenting process. The quality of a paper can also be improved by the great number of comments received. A discussion thread on a social network can be the usual form of open peer commenting.

F. Transfermation of Editor's Function by Aritifical Intelligence

Improving the quality of a paper through academic communications is what open peer review emphasizes on. So, as a bridge connecting reviews and authors, the role of editor should also change in the new model. An editor's major duty is to select papers and reviewers based on their knowledge in the traditional peer review model. Editors also helps authors and reviewers be in contact with each other and decide whether a paper can be published according to reviewers' opinions. Editors should reduce their personal influence on selection of papers for open peer review (for example, *Nature*'s editors filter papers based on their own interests) and give that power to reviewers. For post-publication open peer review platform like *F1000research*, an editor's work mainly happens in the early stage of the review process: an editor examines a paper's soundness and basic quality and leave the rest of the work to its author(s) and reviewer(s), functioning in an auxiliary role [12].

Artificial Intelligence is a comparatively new technology field that studies the theories, methods and applications of simulated human intelligence. Natural Language Processing, Machine Learning, and Neural Networks can effectively be used to examine the data embedded in a paper and to extract subject terms, which can help reviewers make informed decisions on the qualities of a paper and/or on finding reviewers more suitable to review it. The technologies can also help predict the future impacts of a paper in an open peer review system.

Many academic publication groups and information technology companies are turning the idea into practice. *Elsevier* adopts *Aries Systems*, a peer review management system, based on which it has developed a software called as *StatReviewer* to check the soundness of data and methodologies in a paper. *ScholarOne*, a peer-review platform, is collaborating with *UNSILO of Aurhus* (Denmark) using Natural Language Processing and Machine Learning to extract the subjects of a paper [4]. *Meta lnc* company (owned by *Chan Zuckberg Initiative*) uses AI to analyze a paper, providing their editors with the relevant data in order for them to be informed with the frontline research works and to predict the future of science.

V. Conclusions

The purpose of open peer review is to address the defects in traditional peer review by using measures conforming to the open and democratic spirits of Open Science. Open peer review did not perform well as it could be seen from the results of *Nature*'s 2006 experiment. When it came to its 2016 experiment, despite the great improvement in the opt-in rate, the level of openness was even less than that of the previous one. It should be noted that as a new creation, open peer review in practice is still negatively affected by various issues, which could be effectively addressed by the CS related technologies.

On Feb 5, 2020, Nature's official website announced the selection of the open peer review process, which can be regarded as reflecting *Nature*'s experiences gained from the previous two experiments and its final recognition of the worthiness of open peer review. With the rapid developments in technology and the quickly-growing Open Science movement in social environments, open peer review will certainly bloom when the issues are successfully addressed.

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