OPINION PAPER

Readersourcing—A Manifesto

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This position paper analyzes the current situation in scholarly publishing and peer review practices and presents three theses: (a) we are going to run out of peer reviewers; (b) it is possible to replace referees with readers, an approach that I have named "Readersourcing"; and (c) it is possible to avoid potential weaknesses in the Readersourcing model by adopting an appropriate quality control mechanism. The readersourcing.org system is then presented as an independent, third-party, nonprofit, and academic/scientific endeavor aimed at quality rating of scholarly literature and scholars, and some possible criticisms are discussed.

Introduction

Scholarly publishing, the main mechanism to spread scientific knowledge, is based on peer review, the judgment by colleagues of the quality of submitted papers. I first briefly summarize the current practice of peer review in scholarly publishing and emphasize some of the critical aspects. Then, I present evidence of a specific problem in scholarly publishing: We are "running out of reviewers." Next, I illustrate my proposal to outsource the quality control mechanism usually performed by peer review to the "crowd" of readers, an approach I have named "Readersourcing." I also describe a mechanism to cope with the most obvious objection to *Readersourcing*, i.e., that expert readers can provide more correct and reliable judgment on the papers they read, and a prototype implementing that approach. Finally, I discuss some reactions to the proposal and conclude the paper.

What's Wrong With Peer Review?

How do scientists work? We all know: A researcher has an idea, or discovers some new phenomenon, does some theoretical or experimental work, writes a paper, and submits it to a journal, a conference, a workshop, or any other appropriate forum. The paper is not immediately published; it first has to pass *peer review*, a process in which some peers—i.e., other researchers who are, one trusts, as expert as the author—read the paper and judge it. Then an editor makes the final decision on the basis of the referees' remarks. If the decision is positive, the paper will be published. This process is called *scholarly publishing*, and it is common to many—though not all—research fields. Peer review is a crucial element of the process, as well distilled in the famous phrase by Stevan Harnad, "the invisible hand of peer review," that synthesizes the fundamental role of peer review(ers) in keeping the quality of scholarly literature at a high level.

The above-mentioned description is oversimplified, and several aspects have been left out. For example, several forms of published material exist, including books, theses, reports, and so on. There are important differences across disciplines. Not all published work undergoes peer review, and there are several variants to the basic peer review process (see, e.g., Akst, 2010; Meyer, 2010): anonymous (blind, double blind) versus open, with a meta-reviewer, with rebuttal, and so on. It is also important to note that the contemporary practices of scholarly publishing and peer review were not born in a vacuum. Rather, their current status has been reached after centuries of social, economic, and technological progress and changes that include, for example, the so-called Republic of Letters, the habits of circulating preprints among scholars, and the first scholarly journals in the 17th century. In particular, current peer review and scholarly publishing were not born together: at first, because the number of submitted papers was low, the editor of the journal could review them; peer review was added later to cope with the increasing number of submitted papers, and their increasingly specialized levels.

Much more recently, during the 1990s, the coming of the Internet, e-mail, and the World Wide Web fostered electronic scholarly publishing—replacing "paper mailing" with faster

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electronic communication and developing novel forms of publications, in terms of multimedia, data/databases, software, etc.

Today, electronic scholarly publishing is a reality. Even more interesting, the Web—and more recently the Web 2.0—encouraged, inspired, or simply made possible alternative publication models as well: "do-it-yourself publishing" (anyone can "publish" on a Web page whatever he or she wants, without any peer review); open access (scientific publications should be freely accessible by anyone); commentaries (a paper is published together with comments by other authors); and so on. Made feasible by Web 2.0, , these proposals were labeled "Science 2.0," and this label includes more innovative approaches as well: for example, the concept of publication proposed by the Liquidpub project,[1] which advocates a more "liquid" notion of paper (i.e., wiki-like, although this is an oversimplification).

Having set the background, let us analyze peer review, and criticisms thereof, in more detail. Peer review was being criticized even before the Science 2.0 innovations (see the Wikipedia article on "Peer Review"[2]), which is not surprising. Peer review is sometimes simply "wrong," because the reviewer does not always understand the submitted paper (i.e., sometimes the reviewer is not good enough to be a "peer" of the author). Sometimes peer review takes too much time. It is probably one of the causes of the so-called "positive bias,"[3] i.e., the bias toward publishing mainly positive results, which is a problem particularly in some fields such as medicine. It tends to suppress dissent from "mainstream" theories. Of course, peer review is subjective to some extent, and sometimes it is simply inadequate because, for example, the referee cannot replicate complex and long experiments, and an act of faith—that the author is honest—is required (Arms, 2002). Indeed, peer review is not designed to detect fraud: In the past, fraudulent misconduct by authors has been detected by readers rather than referees (Service, 2002). Conflict of interest is also sometimes an issue, because the referee can hinder or favor papers from competitors or friends.

Two authoritative quotations, also included in the above-cited Wikipedia article on peer review, are useful to provide a measure of the problem. Richard Horton, editor of *The Lancet*, stated:

> The mistake [. . .] is to have thought that peer review was any more than a crude means of discovering the acceptability—not the validity—of a new finding. Editors and scientists [. . .] insist on the pivotal importance of peer review. We portray peer review to the public as a quasi-sacred process that helps to make science our most objective truth teller. But we know that the system of peer review is biased, unjust, unaccountable, incomplete, easily fixed, often insulting, usually ignorant, occasionally foolish, and frequently wrong.

Drummond Rennie, deputy editor of the *Journal of the American Medical Association*, stated:

> There seems to be no study too fragmented, no hypothesis too trivial, no literature too biased or too egotistical, no design too warped, no methodology too bungled, no presentation of results too inaccurate, too obscure, and too contradictory, no analysis too self-serving, no argument too circular, no conclusions too trifling or too unjustified, and no grammar and syntax too offensive for a paper to end up in print.

More anecdotal evidence is provided by the well-known story of the rejection of the Google/PageRank submission by ACM SIGIR reviewers in 1996 (allegedly because there was no evaluation), and the birth of *Rejecta Mathematica*,[4] "a real open access online journal publishing only papers that have been rejected from peer-reviewed journals in the mathematical sciences," not to mention the bad review(s) that any researcher has received at some point in her career.

Another clue that peer review is somewhat under attack is the above-mentioned large number of variants and changes to the peer review process (Akst, 2010; Meyer, 2010). Even more radical approaches like Liquidpub (see above) suggest collaborative reviews and/or a more distributed peer review practice.

So, to make a long story short, and to summarize this section: Scholarly publishing and peer review are reasonably effective ways to achieve effective scholarly knowledge communication, with an a priori, prepublication quality filter; however, they are not perfect, and their limitations are also often perceived in the field, as shown for instance by a recent large survey among authors and reviewers.[5] Therefore, it makes sense to study alternative approaches.

A Problem: Referees as a Scarce Resource

The first thesis of this paper can be stated as follows:

Thesis 1. We are going to run out of good referees.

Why? To support this thesis, I will analyze briefly 10 factors. First, however, note that the increasing number of scholars is not a problem per se: More researchers imply not only more papers, but more referees as well.

1. *Technology.* Writing is made easy by technology. We have better and more powerful tools for writers today than 20–30 years ago: text editors, cut-and-paste functions, search engines, bibliographic management software, e-mail, teleconferencing and videoconferencing tools, spell-checkers, etc. None of these tools was available, say, during the 1970s, when authors wrote papers by hand or on a typewriter. Also, copyediting was more cumbersome, whereas today it is quite common to leave it to authors (and software), who are requested to provide a camera-ready copy. Thus, the progress of technology leads to more publications—and to more submissions as well.

[1] liquidpub.org
[2] en.wikipedia.org/wiki/Peer_review
[3] en.wikipedia.org/wiki/Publication_bias
[4] www.rejecta.org
[5] www.senseaboutscience.org/pages/peer-review-survey-2009.html

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2. *Publication opportunities.* The number of publication opportunities is increasing. Technology makes the creation of publication venues and forums (e.g., conferences, journals) easier by means of conference management software, journal submission sites, and similar tools. More publication opportunities of course lead to more submissions.
3. *Publish or perish.* There are strong career pressures to publish more, commonly characterized by the famous "publish or perish" maxim. But such concepts as "least publishable unit" and "salami publishing," referring to the practice of publishing in small increments in place of a single good publication, also point to the pressure. This "arms race" leads to more publications/submissions per researcher, and thus more submissions in general.
4. *Shameless resubmissions.* Rejection is no longer a problem: A rejected paper can be just resubmitted to another venue, with minimal effort. Because most of the submissions are done electronically, we could speak of "one-click-away resubmission." Also, *Rejecta Mathematica* (see above) is a last resort. Of course, this leads to more submissions as well.
5. *Paper and pencil.* On the other hand, technology has not improved the reviewing activity as much. Peer reviewers still rely on paper and pencil for their work. It is true that e-book readers, search engines for plagiarism, and similar tools can help, and that often the referee report is written and submitted electronically; nonetheless these are only minor improvements for the referee work itself, an activity that has been unchanged for decades. Thus, reviewing is as difficult as it was two centuries ago, or perhaps even more, because papers are often very specialized or interdisciplinary in content, and the referee is often required to provide his or her report very quickly.
6. *No reward. No accountability*. Good referees are not rewarded, and bad referees are not penalized. At least, this does not happen to a large extent, in public, and systematically. On the one hand, it is true that program committees and editorial board members keep good and bad referee lists, that rumors sometimes spread among colleagues, that a best reviewer prize is sometimes awarded, and so on. However, on the other hand, these are just palliatives: They stay at the level of personal communication or little more, and it is clear that there is no rational or compelling reason to be a good referee. Gene Golovchinsky states it well in his blog:[6] "[T] only reward for good reviewing is more reviewing."
7. *More cooperation.* Cooperation and coauthorship networks are growing, for several reasons, including the development of cooperative tools, ease of traveling, the Web, and more. Also, doing research and authoring are far more cooperative than reviewing, and always have been (Cronin, 2009). Therefore, because of increasing cooperation, more research is done and this leads to more submissions. Furthermore, the increasing number of coauthors also makes it more difficult to find referees, because they cannot be chosen among coauthors.

[6]palblog.fxpal.com/?p=2230

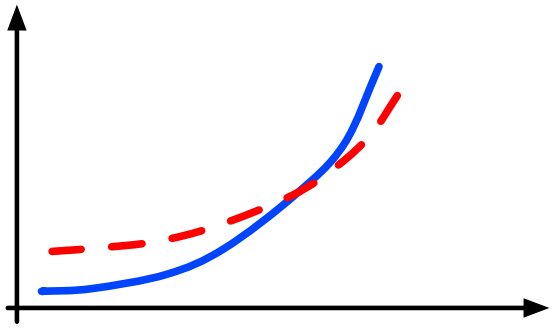

FIG. 1. Submission (blue) and reviewing (red, dashed) forces. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

8. *Specialized circles.* Science is often done within smaller and more specialized research fields. Since in small circles everyone knows everyone else, conflict of interest and anonymity become more serious concerns. This phenomenon increases the number of cases in which it is more difficult to find referees.
9. *Money.* Although, as discussed in item 6, in the vast majority of cases referees are not rewarded, some journals are beginning to pay referees (indeed, referees of research projects are usually paid already). Would they if not needed? A related proposal in this direction has been made by Fox and Petchey (2010), who suggest that reviewers be rewarded in an artificial currency that can be spent later on publication.
10. *Open access.* Although open access is a threat to current commercial practices of publishers, scholars and authors would like to have their papers fully accessible, and at least one has decided not to act as a referee for publishers not providing open access.[7] Here we have another reason to have even fewer referees.

In summary, it can be said that in the scholarly publishing world there is a strong and quickly increasing "submission force" (as detailed in items 1–4, 7), whereas the "reviewing force" is not so strong and is not increasing so quickly (items 5–10). If this is true, then at some point the submission force will overtake the reviewing force, as represented in Figure 1, and the system will collapse. Leaving ethical considerations aside, if being a good referee is not an evolutionarily stable strategy,[8] then good referees will be constantly more scarce.

I am not alone in supporting this thesis, and there are even more extreme positions (see, e.g., Fox & Petchey, 2010); however, there is also the opposite view, that there is no peer review crisis at all, even supported by some data (Vines, Rieseberg, & Smith, 2010). In the following, I will nevertheless assume that I have convinced the reader that my thesis is true, at least as a (reasonable) working hypothesis.

[7]www.crypto.com/blog/copywrongs/

[8]en.wikipedia.org/wiki/Evolutionarily_stable_strategy

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A Proposed Solution

Readersourcing

So, we do not have enough referees. Is there any solution? The second thesis of this paper is as follows:

Thesis 2. We have plenty of readers!

Readers read papers, and they form an opinion about the paper. Moreover, readers are many; therefore, potentially at least, there is a quite strong reading—and reviewing as well, in the sense that I will discuss shortly—force. The number of papers that each researcher reads per year is at least one order of magnitude higher than the number of papers that he or she writes: Tenopir and King (2008) report almost 300 (and increasing) papers read per year in 2005, whereas the number of papers written per year is probably around 10 on average. The latter figure is even lower when one considers that writing often means coauthoring, whereas reading is done alone. Moreover, this estimate does not take into account the readers who do not publish, such as students. However, this reading/reviewing force is not used at all, and readers' opinions are quite likely to stay closed in their own mind—and probably forgotten after some time.

Using many readers in place of a few referees can be viewed as a form of *crowdsourcing*. Crowdsourcing is a term proposed by Jeff Howe (2008) and means "taking a task traditionally performed by an employee or contractor, and outsourcing it to an undefined, generally large group of people or community in the form of an open call" (see also the Wikipedia article on "Crowdsourcing"[9]).

Notable examples of successful crowdsourcing include the following: the "Kasparov versus the world" chess match played in 1999; Wikipedia, whose quality seems comparable to more classical encyclopedias (Giles, 2005); the well-known open-source movement in software; several Web sites and services, for example, t-shirt design (threadless.com), photography (iStockphoto), research and development (Innocentive); and the rise of crowdsourcing platforms and markets, such as Amazon Mechanical Turk,[10] that allow their users to outsource to the crowd simple tasks for a small amount of money. Of course, not everyone is a crowdsourcing enthusiast: for a critical viewpoint, see Keen (2008) or the Wikipedia article on "The Cult of the Amateur."[11] Indeed, the expression "wisdom of crowds" predates crowdsourcing, and it is well known that, in some cases, a crowd can be as wise as, if not more than, a small group of experts.[12] What the number and variety of these examples of success tell us is that crowdsourcing is rather common and seems to be effective.

Peer review is not crowdsourced: a few referees do the job (if they can be found, given the analysis in the previous section). What is particularly striking is that it is quite strange that the Web 2.0 tools and approaches that we developed are not used by us where they can be naturally applied. The cobbler's children go barefoot.

Actually, it is even worse. Indeed peer review *is* crowdsourced! As a matter of fact, readers read the papers, and often the readers are as expert as the original referees, thus the crowd at work seems a particularly good one (although of course it also contains several others who are not such experts, as with any crowd). But the results of this crowdsourcing process are not exploited, because readers' opinions are not made public.

So, summarizing, the proposed solution to the problem presented in the previous section is to crowdsource peer review to the readers. More precisely, my proposal is (a) to allow and encourage the readers to express their opinions as ratings on the papers that they read and (b) to collect and aggregate those ratings to distill a reliable quality score for each paper. I call this approach *Readersourcing*. In its purest form, Readersourcing would replace peer review: Authors would directly publish their papers on the Web, with no peer review, and readers would read, judge, and rate them. However, it is also easy to imagine Readersourcing as coexisting with peer review: Some of the published papers might undergo the usual a priori filter of peer review. In both cases, Readersourcing would allow us to obtain quality scores for papers and researchers, as detailed below.

Quality Issues

Readersourcing is a solution to a problem, but it immediately raises another problem, for which we need a solution: how to distinguish good readers from bad readers. If 200 undergraduate students say that a paper is good, but five experts (by reputation) in the field say that it is not, then it seems obvious that the latter should be given more importance when calculating the paper's quality. In other words, what is needed is a mechanism that

- (a) weighs good and bad readers appropriately and
- (b) updates readers' importance according to their behavior, to be able to do (a) and to generate a virtuous behavior, where readers need to provide correct judgments to keep their reputation high.

The third thesis of this paper is that it is possible to design a mechanism such that:

Thesis 3. It is rewarding to be a good reader.

Actually, I have already proposed and precisely described such a mechanism (Mizzaro, 2003), which builds on readers' reputations. It defines an objective measure of reader quality, which readers will try to maximize to keep their reputation high. More precisely, the mechanism is based on papers, authors, and readers, each one having a quality score. Paper scores measure the quality of papers; author scores change according to the scores of the papers published by each author (using weighted averages of paper scores). Each reader has a score, too, different from the author score. Judgments by readers who score high are

[9] en.wikipedia.org/wiki/Crowdsourcing
[10] www.mturk.com
[11] en.wikipedia.org/wiki/The_Cult_of_the_Amateur
[12] en.wikipedia.org/wiki/The_Wisdom_of_Crowds

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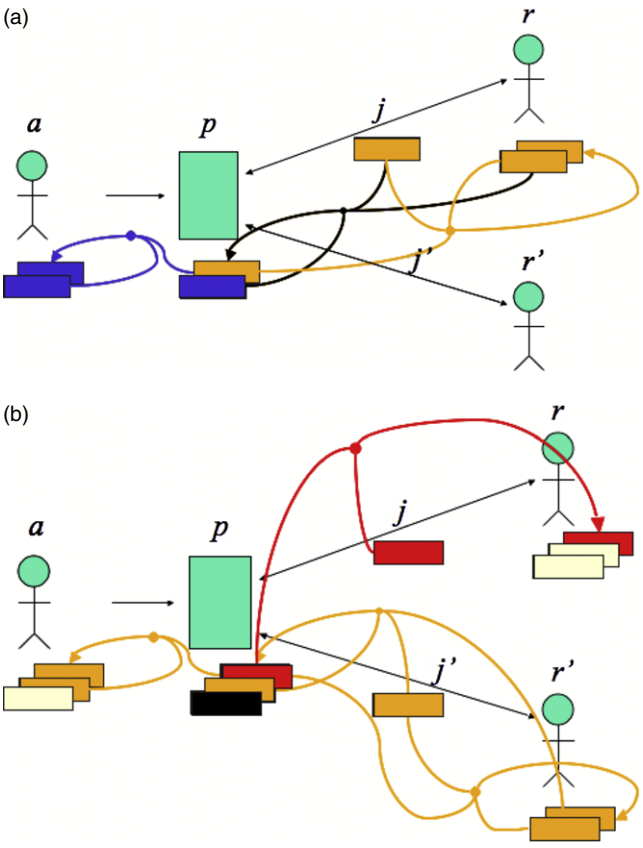

FIG. 2. A toy example: The small rectangles represent the scores. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

weighted more heavily when computing the average that leads to the score of a paper.

Also, the reader score is a measure of the reader's reviewing capability and it is revised according to the correctness of expressed judgments (right judgments mean a higher reader score and wrong judgments mean a lower reader score).

The last piece of the puzzle is to define what a right judgment is. In theory, it is equal to the final paper score (the score that the paper will have at time = $+\infty$). In practice, the score at time $+\infty$ is not available but it can be approximated by the current score. Also, this approximation can be revised over time as we get closer to $+\infty$.

Figure 2 shows a toy example: When the first reader r expresses her judgment j on the paper p, the scores of p, its author a, and r change (Figure 2a). When a subsequent reader r' expresses her judgment j', the same updating operations take place on p, a, and r'; but the correctness of j is recomputed as well, on the basis of the new score of p, and the score of r is revised accordingly (Figure 2b). With this mechanism, readers "bet on the score the paper will have."

The last ingredient is steadiness: Authors, readers, and papers also have a steadiness value that measures how stable a score is. Papers published long ago (and often read) have a high steadiness value; "new" authors whose papers are not yet read as often have a low steadiness; and readers who expressed many judgments have a more stable reader score. Steadiness values change (increase) as well over time.

The aim of this mechanism is to create a "virtuous circle," where authors try to publish good papers, readers try to express good/correct judgments, the score and steadiness of papers can be used (along with the usual tools such as search engines and citations) to decide which papers to read, authors' scores measure their scientific productivity, and readers' scores measure their scientific reputation and are used to weigh the judgments of the readers and "to tell good readers from bad ones." Being a good reader (referee) is an evolutionarily stable strategy. Also, this is a more precise mechanism than the much-discussed metrics based on citations (impact factor, h-index, etc.): whereas there are several reasons to cite, or not to cite, a paper, the score expressed by a reader is a quality assessment act that is much more compelling than a citation.

Some software simulations show that, under reasonable assumptions, there is no problem with "lobbies" (people mutually giving high scores), lazy readers (i.e., readers simply confirming the current score of the paper), and other malicious behaviors aimed at gaming the system (see Mizzaro, 2003, for details). Also, the mechanism has been applied to quality rating of Wikipedia articles (Cusinato, Della Mea, Di Salvatore, & Mizzaro, 2009), with some adaptations since no explicit judgment is available[13] and the amount of change to an article is assumed to be a reliable implicit judgment of its quality. Indeed, the system seems even more generally applicable, and its application to peer assessment (students assessing the quality of other students' exercises, with the instructor assessing—with the final and correct score, which is not available in peer review—only a small sample of the answers) is in progress, with promising preliminary results. Also, a simplified version has been applied to a social context-aware browser for mobile devices, and the results of its evaluation are promising (Mizzaro & Vassena, 2011).

readersourcing.org

The Readersourcing model is not only theoretical. It has been developed into a concrete application, still in beta but almost complete and available at www.readersourcing.org. It aims to collect paper judgments and to compute scores according to the mechanism described above. A Firefox plugin will also be available to allow readers to express their judgments without connecting to the Readersourcing Web site.

Therefore, Readersourcing can be defined as an independent, third-party, nonprofit, and academic/scientific endeavor aimed at quality rating of scholarly literature and scholars.

[13]The recently added "Rate this page" feature for Wikipedia was not available in 2009.

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It is probably worth justifying the choice of a new implementation from scratch, given the high number of "rating" services on the Web (YouTube, eBay, Amazon, Slashdot, Digg, Epinions, reddit, etc.), some of which are explicitly aimed at, or are easily adaptable to, scholarly publishing (CiteULike, Mendeley, ACM DL, DBLP, Connotea, Diigo). Because all these are privately owned in some way, the question of who owns the data arises. The aim of Readersourcing is to keep the data public, to foster accountability, and to provide an alternative scoring mechanism. Also, the same person will have different identities on the above-mentioned services, and this would make the computation of the scores more difficult. A centralized solution would help.

It is also worth mentioning PubZone,[14] which is very similar to Readersourcing, though it is aimed at the database community and the underlying score mechanism is different.

Discussion

There are several objections to Readersourcing. Due to space limitations, I list here only the most common criticisms together with some answers (see Mizzaro, 2003, for more discussion, as well as results of some software simulations).

An initial objection is that because Readersourcing is an a posteriori filter, whereas peer review is an a priori one, the quality of scholarly literature would decrease. There are some answers to this:

- Even with peer review, it is not clear that a filter is actually in place: see Rennie's quotation above, or pick your own preferred fraud case among several instances; for example, the well-known "Schön affair" (Service, 2002) or the more recent one concerning a psychologist.[15]
- Even if the number of published papers increases, the reader can still find the good ones when a quality score is attached to all of them.
- Nothing prevents applying Readersourcing and classical peer review together, with the former acting as a sort of surrogate to the latter when needed (e.g., when there are no referees).

On a related issue, the comments of peer reviewers often help to improve the papers. The disappearance of this function could be harmful, but it is also easy to imagine some social dynamics that can replace it: commentaries, in a blog-like fashion, can be added to papers; because the paper and its score will be out there forever, authors might seek informal peer reviewing before publication (as is already done in the high-energy physics community, where a major publication target is arXiv.org, a paper repository with no peer review); some papers (perhaps only the most interesting or most discussed) might be revised after their publication; and an even more "liquid" notion of paper (see footnote 1) might develop in this environment.

[14]pubzone.org

[15]www.nytimes.com/2011/11/03/health/research/noted-dutch-psychologist-stapel-accused-of-research-fraud.html

Another common objection is that referees must read the paper, whereas no reader is forced to read any specific paper; as a consequence, some papers could have very few (even zero) readers, and therefore their quality would not be assessed. However, this does not seem to be a major concern: Unread papers will go unnoticed, and papers read by very few readers will perhaps have a high score, but also a low steadiness rating (so they can be easily distinguished from good and well-established papers, and if, in time, they are found to be not so good, their score will drop rapidly). Similar considerations apply to authors.

Another issue is that currently readers and referees bring different approaches to reading. For example, readers apparently assume that the a priori quality filter has already been applied, and they often peruse only a part of a paper. This resembles the common criticisms of crowdsourcing, but the above-listed successful crowdsourcing examples suggest that, in some cases at least, the quantity (i.e., the crowd) is a good surrogate for the quality (i.e., a few experts). It is also easy to imagine a slight improvement to the mechanism that would allow readers to judge only a specific portion of the paper; indeed, a similar solutions has been used in the Wikipedia model, with edits in place of the papers of the original model (Cusinato et al., 2009). Also, reading habits are likely to change and become more careful, because the expressed judgments will affect readers' reputations.

One critical issue in Readersourcing is identity, which could probably be solved by some institutional commitment, i.e., researchers willing to participate in readersourcing.org should obtain a sort of token from a recognized research institution (university, research center, etc.). Currently, the system is based on an invitational process that requires a new member to be invited by someone already in readersourcing.org.

A last problem is social acceptance: Will scholars spend time to express judgments? Will they accept an "objective" score? Will established and authoritative researchers get high scores because of their status? The social aspects of this kind of system are extremely complex, and it is impossible to foresee what would happen, so I prefer not to speculate in detail. But it is important to note that the Readersourcing environment is particularly favorable, more than the usual crowdsourcing examples, because its crowd is made up of several people who are just as expert as the original referees (plus, admittedly, several not-so experts, as in any crowd).

Conclusions

Readersourcing, an independent, third-party, non-profit, and academic/scientific endeavor aimed at quality rating of scholarly literature and scholars, has been presented and defended against some possible criticisms. I have emphasized some aspects that make the proposal attractive: the high number of available readers and "readings"; the quality of this particular crowd; the weaknesses in the current system; the technological facilitators that make it possible in the current Web arena; the existence of similar and success-

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ful crowdsourcing examples; the fact that most of the intellectual work (i.e., the reading of papers) already takes place and is wasted; and so on.

I also touched upon some still-unresolved issues: social acceptance, gaming attempts, the disappearance of the role of classical peer review that improves the papers, etc. Therefore, only further simulations and analyses, and perhaps only the final deployment and use, will determine if Readersourcing will be successful.

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