Scholarly Communication and Peer Review

The Current Landscape and Future Trends

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Executive Summary

Peer review plays a central and critical role in the systems of publishing and communicating research results, from the perspectives of researchers and also of publishers. There is currently much experimentation in different approaches to peer review, both pre- and post-publication. The experiments are in part a response to concerns – some of them longstanding, others that have arisen more recently – about the effectiveness and fairness of current systems. But they have also been stimulated by the potential of new technologies, and new entrants to the scholarly communications market.

The key concerns relate to the rise in the number of number of papers being submitted for publication, and the pressure on researchers to secure publication, especially in high-status journals. This pressure is passed on to publishers and editors who need to ensure that their peer review and other checks act as effective filters against the publication of work that does not meet appropriate standards or, worse, involves misconduct or fraud. They therefore worry about difficulties in recruiting high-quality reviewers; about the need to provide them with effective support, guidance and training; and about the risks to the reputation of their journals – and even to the scholarly publishing system as a whole – when pre-publication review fails to detect papers with major problems. On the other hand, many publishers are also concerned about over-critical or negative reviews, and the need to ensure that reviewers do not make unreasonable demands on authors, or set impossible standards. Achieving an appropriate balance between properly-rigorous review on the one hand and unduly critical review on the other is not easy, and publishers are taking various steps to enhance their ability to achieve it.

There are many vocal critics of current approaches to peer review, and advocates for new systems and approaches. But publishers stress the need to avoiding getting too far in advance of the different subject communities they serve. The cultures of those communities are very powerful, and journals and publishers are keen to avoid the risk of alienating key sections of them. Hence many innovations, even from the newer entrants to the market, are introduced as pilots and/or on an optional basis; and we are unlikely to see widespread abandonment, for example, of pre-publication in favour of post-publication review. Editors play a key role in advising publishers on what is or might not be acceptable; and their role is likely to be enhanced as the pace of experiment quickens in six key areas.

First, there is widespread acknowledgement of the need to move towards greater transparency and openness in the review process. But there is a clear distinction to be made between openness as to *reviewers' identities* on the one hand, and the *content of reviews* to readers as well as authors on the other. In many subject communities, the former is likely to be less acceptable, at least in the short term, than the latter.

Second, there is common agreement on the desirability of more interaction between editors, reviewers and authors. More ambitiously, many publishers wish to see more dialogue not

just between all those involved in pre-publication review, but also with those engaged in post-publication comments, reviews and ratings.

Third, more and more publishers are seeking to provide article-level metrics, going beyond the views, downloads and citations to include - with the help of services such as Altmetric, Plum Analytics, and Impact Story - a range of metrics relating to comments and ratings, mentions in social media and news sites, bookmarking and so on. There is debate about how the metrics are generated, the weightings attached to different measures and the extent to which they are aggregated, and so on. But they are an increasingly important feature of scholarly publishing.

Fourth, there is increasing interest in the provision of rewards in the form of scholarly credit and recognition for reviewers. Both publishers and start-ups such as Publons and Peerage of Science are keen to give proper credit for the contributions that reviewers make to the research community. There is little enthusiasm – rather the reverse – for any suggestion of monetary rewards. But recognition not just of the quantity but also the quality of reviews is likely to become an increasingly-significant part of the landscape.

Fifth, there are renewed efforts to improve guidance, training and feedback for reviewers; and assessment and ratings of reviews and reviewers. Such efforts are essential if the peer review system is to sustain the confidence of the research community.

Sixth, there is increasing interest in differentiating between the distinct but related purposes of peer review. The rise of mega-journals such as *PLOS One* and *Sage Open* has highlighted the usefulness of seeking to distinguish between whether the research on which a paper is based is sound and thus worthy of publication, and whether it fits with the nature, scope and ambitions of the journal to which it has been submitted. Not least, such a distinction can help reduce the redundancy of effort involved when papers are submitted successively to more than one journal. Publishers are making increasing use of 'cascade' systems to avoid reviewing papers more than is necessary, and they are keen to do more. Whether third-party review services will increase in role and scope, is not yet clear.

In addition to these six key areas, however, we have detected through our study a sense that publishers would welcome more guidance from key sections of the research community on the kinds of peer review services they want publishers to provide, and on the purposes that they should seek to fulfil. Unless the purposes are defined with greater clarity than they are at present, at least some of the current experimentation may prove to be of little point.

1. Introduction

Recent studies (Ware 2008; Sense About Science 2009; House of Commons Science and Technology Committee 2011; Mulligan 2012) have all confirmed that members of the research community attach fundamental importance to the *principle* of peer review for research publications, at least in general terms. But groups of researchers, publishers and editors all frequently express concerns about the *practice* of peer review; and recent years have seen a number of experiments and initiatives which modify established practices in significant ways. The dynamic of the relationships between principle and practice, however, have not been systematically investigated.

Thus we lack at present any clear or systematic view of authors', publishers' and editors' adoption of new practices such as open and interactive review; cascade or portable review; post-publication review, comments and ratings (including the use of social media); the use of independent peer review platforms; and so on. Similarly, we lack systematic evidence on the plans or proposals of publishers and editors to introduce any changes in review systems, processes and workflows; or on researchers' expectations (as authors and reviewers) of necessary and/or likely changes in the mechanics of peer review over the next three to five years.

Our aim in this brief report is to examine the current landscape of peer review for research publications, including recent innovations and how they have worked in practice; and to gather and appraise the views of publishers and others as to how systems and processes may change over the next four to five years.

Our work has involved a mixture of desk research and interviews, but we should draw attention to some key limitations. First, although we have gathered a good deal of information from journal literature, reports, publishers' and other providers' websites, and from social media, we have not attempted a full literature review. Second, our interviews have focused on publishers (both well-established and new) and some of the newer independent peer review platforms; but we have not attempted any systematic review of the experiences and perceptions of members of the research community, in their capacities either as editors, reviewers, authors or readers.[1]

Nevertheless, we believe that within these limitations, we have been able to delineate the key features of the current landscape, and the changes that are currently taking place; and to identify some key trends for the future. Members of different parts of the research community themselves, however, will play a key part in determining future developments

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[1] We have made use, however, of the results of a 2009 survey of researchers reported in Mulligan et al's 2012 paper in the *Journal of the American Society for Information Science and Technology*. And we note that a more recent survey undertaken by the. Nuffield Council on Bioethics, as reported in *The Culture of Scientific Research in the UK*, 2014, suggests that 71% of respondents believed that the peer review system in the UK is having a positive or very positive effect overall on scientists in encouraging the production of high-quality science.

in the practice of peer review; and we hope in a future stage of this work to investigate in depth their experiences and attitudes, as well as their thoughts on such developments. For there have been some significant changes in the peer review landscape since the last major review of the experiences and attitudes of over 4,000 researchers worldwide undertaken in 2009 by Sense About Science (as reported in Mulligan et al, 2012).

2. Scholarly communications and journals

Communicating the results of research and sharing new findings are critical to the progress of science and of scholarship more generally. The development of effective channels of communication between researchers across the globe has been a critical factor underpinning the growth in our understanding of the world over the past 350 years. Since the establishment of the first scientific journals in 1665, the communication of theoretical and empirical findings through such journals and other publications has been at the heart of the scientific and broader research enterprise. The core functions of these journals were identified by Henry Oldenburg, the first Secretary of the Royal Society and the creator of its *Philosophical Transactions*:

- ❑ registering the findings, their timing, and the person(s) responsible, thus recording the authors' precedence and 'ownership' of an idea or finding
- ❑ reviewing and certifying the findings before they are published, thus providing quality control and assessing the validity of a scholarly claim
- ❑ disseminating the new knowledge, and communicating it to the intended audience
- ❑ preserving a record of the research and findings for the long term, thus preserving the 'minutes of science'.

Communicating research results through journals has proved remarkably effective in enabling researchers to build on the work of others, to scrutinise and refine the results, to contribute additional ideas and observations, and to formulate new questions and theories. They also help to build up the 'invisible colleges' of researchers working in fields of common interest. Peer review has been fundamental to the success of journals in fulfilling all these roles.

But particularly in recent decades, journals have come to play an additional role, as a key source of evidence of both the volume and the quality of the performance of individual researchers, research teams, institutions and even nations. Individual researchers gain recognition and career rewards - in the form of appointments, promotions, research grants, and approaches from potential collaborators - by publishing their work in journals. The rewards can be particularly significant if researchers secure publication in a high-status journal, or (which is a rather different measure) if their articles secure large numbers of citations or (different again) high scores in the various newer measures of impact and usage, often referred to as altmetrics. Universities and other research institutions (and for individual departments within them), are interested in such measures of the performance of their researchers and teams in the aggregate not only because high levels of performance

enhance their reputations, but also because they a major influence on institutions' ability to attract high-quality staff, and to win more funding and grants to support their research.

Many commentators suggest that this additional role of the scholarly communication system – the conferring on authors of scholarly credit and reputation - has come to predominate over all others, with damaging consequences. For there is intense pressure on researchers to publish, and especially to publish in high-status journals where their work may be thought – rightly or wrongly – likely to secure most attention and impact. As a recent report from the Nuffield Council on Bioethics put it

> publishing in high impact factor journals is still thought to be the most important element in determining whether researchers gain funding, jobs and promotions, along with article-level metrics such as citation numbers. This has created a strong pressure on scientists not only to 'publish or perish', but to publish in particular journals.

These pressures are reflected on to publishers, journals, and editors; and they have a profound impact on reviewers and indeed on the whole ecology of journals and of peer review. Not the least of these is a concern that the pressure to publish in high-status journals may mean that some kinds of research – for example, negative findings, or work that replicates or refutes others' work - may not be published; or that even if it is, it will be only in a low-status journal where the chances of widespread recognition are lower.

But there are pressures on readers too. There are over 28,000 scholarly journals worldwide, and they publish some two million articles a year, with the numbers growing at 3-3.5% annually. No researcher can keep up with all the literature, even though discovery and reading based on keyword searching for individual articles is becoming an increasingly important part of researchers' everyday practice. Gathering together articles on defined subjects and of interest to specific audiences remains a key way for researchers to navigate their way through what would for many of them be an overwhelming volume of papers.

3. What is peer review and what are its purposes?

Peer review conducted by journals has been defined as 'the process of subjecting an author's scholarly manuscript to the scrutiny of others who are experts in the same field' (Ware 2013). The purpose of such scrutiny is often said to be to assess the quality of the research and the paper. But quality has a number of different elements, and in practice peer review can serve a number of distinct but related purposes.

- ❑ The first and fundamental purpose is to check the work for 'soundness': has the research been performed to reasonable standards, and are the findings and the conclusions drawn from them in that sense valid?
- ❑ A second purpose is to assess the originality, significance and broader interest of the research: is it simply reporting another example of a well-known finding or phenomenon, or is it new and of wider significance and interest;

- ❑ Third, reviewers are asked to assess the 'fit' with the journal to which a paper has been submitted: is the paper likely to be of interest to the readers of this particular journal?
- ❑ A fourth purpose is to help authors to improve the quality of their research and the presentation of their findings: how might the paper be enhanced so that it maximises the credit and rewards that the authors (and the journal) receive as a result of its publication?

The first purpose may be described as an attempt to ensure that only good science or scholarship gets published as part of the 'minutes of science' in the journal literature; and by implication that science or scholarship that does not meet acceptable standards of good practice, or where the findings are judged to be invalid, does not get published in that way. Effective peer review thus provides a certification mark or 'kitemark' that that is valuable both for laypeople and for researchers who are not specialists in a particular field but who may be engaged in interdisciplinary research that requires them to gather information beyond their core area of expertise. Review to fulfil this purpose is undertaken by all journals; and some, notably the newer 'mega-journals' such as *PLOS ONE*, SAGE Open, BMJ Open and Biology Open see this as the major or even the sole purpose of peer review for their journals.

It is perhaps notable, however, that there is no industry standard for signifying that an article has indeed undergone some kind of peer review process. An attempt to address this issue has recently been launched by Striatus, the publisher of the *Journal of Bone and Joint Surgery.* Its PRE-val service – Peer Review Evaluation (http://pre-val.org/) – gathers tagged metadata about the peer review process from publishers' submission and tracking systems and passes the information, along with a badge, back to the publisher for use wherever a signal of peer review is thought to be important, including aggregator and search results services as well as the publisher's own sites. PRE-val thus seeks to verify for end users that published articles have indeed gone through a peer review process, and provides information about the nature of that process. As yet, however, the service has not been widely taken up by publishers.

The second and third purposes of peer review set out above are essentially related to the selection criteria of individual journals and editors, taking account of the nature of the journal and its intended audience. Researchers in the arts, humanities and social sciences attach particular importance to these purposes (Mulligan et al 2012). A key aim here is to provide a filtering service, seeking to identify the papers of greater originality, interest or significance for publication in higher status journals with broad reach. This enables researchers to focus on a set of core journals in their field, supplemented by journals with more niche or specialist coverage, and search and alerting for other relevant articles. Review for these purposes is often described as being distinct from and more subjective than review

for 'soundness'. The people and the processes involved in the review are typically one and the same, though some commentators urge that they should be kept separate.

The fourth purpose is associated especially with high-status journals, which seek to sustain that status by publishing by publishing papers only of the highest originality, impact and significance; and thus to provide a service to authors in helping them to achieve those high standards, and to readers in pointing them to the work of the widest significance and interest in their field. The process can be time-consuming for authors, reviewers and editors, with demands for extra work as well as refinement of findings and conclusions. In the best cases, authors have expressed gratitude for the assistance they have been given in enhancing the quality and impact of their work. In other cases, the demands for extra work can be dispiriting as well as time-consuming. Surveys indicate, however, that the overwhelming majority of researchers find that the process of peer review has improved their papers, not only in terms of presentation, but also by identifying errors and enhancing the accuracy and significance of their findings (Mulligan et al 2012).

4. The roles of editors, reviewers and publishers

Editors

Journal editors play a critical role in peer review: they take the final decision on what is, and is not, published in the journals for which they are responsible. They also have wider responsibilities for the overall policy and direction of the journal, and are appointed by publishers for their expertise and standing in the field. Although editors are appointed by publishers, they act independently of them. In most cases they are academics who are active researchers themselves; but for larger journals in particular, they may be supported by – and in a few cases such as Nature Publishing Group journals replaced by – in-house staff editors.

In peer review itself, editors select the reviewers and assess their reports – which may of course conflict - before deciding whether or not to publish. Selecting the right reviewers for the job, using their own knowledge of the field but also specialist databases maintained by publishers and others, and avoiding potential bias either in favour of or against the authors and the research in question, is particularly important. This work, along with editors' assessments and monitoring of the quality of reviews and reviewers, and feedback to authors, requires in-depth knowledge and understanding, diplomatic skill and careful judgement.

In practice, of course, larger journals tend to have several editors, in order to share the burden, and to ensure that the editorial team as a whole has sufficient expertise across the breadth of the field. The editor-in-chief, however, must still take responsibility for ensuring that the whole peer review system operates effectively and fairly. Editors are also usually supported by an editorial board, whose members sometimes play an active role as editors and/or reviewers, but may in other cases act more in the role of members of an advisory board.

Reviewers

It is important to stress that the role of reviewers is not to decide what should and should not be published, but to make recommendations to editors on the quality of the papers sent to them, usually on the basis of a standard review template devised by the journal. Like editors, they are expected to treat the paper in confidence, to declare any conflict of interest, and to avoid taking any unfair advantage arising from the knowledge they gain from the paper.

Publishers and editorial staff

The staff in publishers' editorial offices usually play mainly support roles in administering and overseeing the peer review process from submission until a final decision is reached by the editor and, if successful, the paper is passed on to the journal's production system. In doing so, they usually supported by manuscript submission and tracking systems such as Editorial Manager (Aries Systems), ScholarOne (Thomson Reuters), eJournal Press, or the open source Open Journal System (these are third party systems; but some publishers have developed their own in-house systems)[2]. These systems store manuscripts, reviews and associated metadata, and provide workflow tools (with appropriate permissions for authors, editors, reviewers and editorial staff) to provide users with the appropriate content at the key stages of the peer review process, along with reporting tools for statistics and management reports.

With the help of such systems, publishers' editorial staff are often involved in checking – even before papers are passed on to editors - that submitted papers fall within the journal's subject scope, and that they meet all of the journal's stated policies and guidelines in relation, for example, to format, research ethics , statements about the contributions of named authors[3], nomenclature codes, providing links to underlying data and so on. They may also be involved in checks against plagiarism (using the CrossCheck system), and testing for image manipulation. Papers which fail to meet these checks will usually be returned to the authors for correction. Editorial staff may also assist the editor in an initial triage stage which aims to ensure that only papers which reach a baseline threshold of quality and relevance are selected to proceed to full peer review. Highly-selective journals may reject a high proportion of articles at this stage. Following this, the editorial staff often assist editors in practical issues relating to the selection of reviewers, taking account of reviewers' known reviewing workload, track record and so on; and in managing the processes of resubmission and review when papers are returned to authors for amendment.

Finally, editorial and other staff play a key role, particularly among larger publishers, in monitoring and providing feedback on the whole peer review process, including the

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[2] Other third party systems include Rapid Review (Cadmus), EdiKit (bepress), EditFlow (MSP), and Scholastica.
[3] The International Committee of Medical Journal Editors and the Council of Science Editors publish criteria on authorship and contributorship.

performance of both editors and reviewers as well as the experiences and perceptions of authors. Such monitoring typically involves surveys and checks on random samples of reviews and published articles. And when issues are raised post-publication about individual articles, editorial and other staff liaise closely with editors about the action that should be taken.

5. Critiques of peer review

It is commonly pointed out that peer review, like all systems based on human endeavour, sometimes fails to fulfil one or more of its intended purposes, and suffers from a number of imperfections. Many commentators have suggested that the best we can hope for is a 'least-worst' system of seeking to ensure that the scholarly communications system works effectively, efficiently and fairly in the interests both of researchers and of the wider community. In seeking to achieve such a system, however, it is important to be clear about the key failures that have been identified.

Efficacy

A number of studies in biomedicine (Jefferson et al 2007) have suggested that peer review does not function effectively as a quality control mechanism. Moreover, in recent years there has been much comment on the rising number of papers that are substantially amended or retracted once they have been published. Evidence suggests (Fang et al 2012) that both the volume and the rates of retraction are increasing, and that high-status journals are no better able - and indeed may be worse - than low-status ones in detecting flawed papers before they are published. The reasons for the retractions and errata noted on the Retraction Watch blog range from investigator error to plagiarism, faked data and image manipulation; and they include all the major research nations and publishers, and subject areas ranging from agriculture and aging, through economics and theology (!) to zoomorphology. Whether the rate of erroneous or flawed publication is actually increasing, or the rate of detection (and thus amendment or retraction) is increasing, is not clear. The numbers of retractions are still very small in proportion to the two million papers published globally each year. Nevertheless, it *is* clear that peer review does not always succeed in ensuring that research is not published unless it meets basic technical and ethical standards. Reproducibility - the requirement that an experiment or study as reported in a published paper should be capable of being reproduced by someone working independently - is often cited as one of the key standards. But as several studies (Begley et al 2012; Mobley et al 2013) have pointed out, a very high proportion of medical research papers are irreproducible. There are considerable efforts now to address this issue (Nature, 2014); but the fact remains that at least until recently, peer review did not ensure that published accounts of experiments and studies were in fact reproducible.

There is also a good deal of evidence to suggest also that peer review does not succeed always in ensuring that the most original and significant papers are published in the most high-status journals. A significant proportion of the papers published in elite journals

receive in the event relatively few citations (in some cases none); and a recent analysis of highly-cited papers (Acharya et al 2014) suggests that a growing proportion of them are published in journals that fall outside the elite group[4]. A smaller study (Siler et al 2015) of papers submitted to three elite medical journals similarly showed that many of those which in the end turned out to be highly-cited were rejected by the elite journals and published elsewhere.

For all these reasons, it is thus clear that peer review is far from infallible in meeting its stated purposes of ensuring that only good research gets published, and that the best papers are published in the best journals.

Burdens on reviewers

It is difficult to get authoritative figures, but it has been estimated that some 3 million papers are submitted to peer-reviewed journals across the world each year. Many are reviewed more than once before they are eventually published (the survey of researchers reported by Mulligan et al 2012 suggests that as authors, their papers were submitted on average 1.6 times before being accepted); and a significant proportion are never published. The same survey suggested that more than half of reviewers spend 6 hours or more on each review; and that as reviewers, researchers were declining invitations to review at an average rate of just over twice a year.

The rise in the numbers of papers increases the pressure on reviewers, and evidence from Elsevier (Mulligan 2013) suggests that global shifts in the research landscape are increasing those pressures for certain researchers. Thus while Chinese authors were in 2012 responsible for 18% of the world's articles, they undertook only 6% of the reviews. It is notable that the low proportion of reviews from Chinese researchers is not because they are unwilling to undertake them: they have a high rate of acceptance for requests to review, but are not asked as often as reviewers from the west. The result is that by contrast, researchers from the USA were responsible for a much higher proportion of reviews than of published articles. Some have argued that this is merely a temporary blip while more researchers from fast-growing research countries such as China and India gain the experience and expertise to undertake reviews. But the imbalance of effort at present is likely to take some time to resolve.

Thus while the great majority of researchers report that they enjoy reviewing and will continue to review, several of the publishers we spoke to said that they were concerned that it was becoming more difficult to recruit good reviewers. And there is evidence of more

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[4] The trend analysis here has been criticised for not taking account of the growth in the number of journals and articles (Davis P, Growing Impact of Non-Elite Journals, Scholarly Kitchen blog 20 October 2014: http://scholarlykitchen.sspnet.org/2014/10/20/growing-impact-of-non-elite-journals/ . But the point remains that large numbers and proportions of the articles that in the event are shown to be most influential as measured by citation impact are published in journals outside the top ten in their broad field.

widespread concern about the 'overburdening' of willing and good reviewers, demanding more of their time that could otherwise be spent on other activities.

Expense and delay

Peer review is undoubtedly expensive, though much of the cost is hidden. A Research Information Network report in 2008 estimated the unpaid costs of the time spent by reviewers across the world each year at £1.9 billion, and it will have risen significantly since then. To that can be added the time spent by editors, some of whom, unlike the great majority of reviewers, receive some payment for their work. One estimate of the costs to UK researchers and their employing institutions of the reviewing and editorial work they undertake puts it at up to £200million a year (Look et al 2010). And that sum does not take account of the time that authors spend in meeting the demands of editors and reviewers for amendments to their papers, or in submitting them to other journals if they are at first rejected.

Publishers themselves also incur significant costs in organising and overseeing the work of editors and reviewers, and in developing and sustaining the systems that enable them to do so. An estimate presented to the House of Commons Science and Technology Committee in 2011 suggested that publishers had invested some £2billion in their systems in recent years; and one publisher to whom we spoke suggested that they spent up to $500 million a year on editorial and peer review work. These costs are passed on in the main to researchers and the institutions that employ them, in the form of subscription and other charges.

Some commentators argue that these costs represent only a small proportion of the global expenditure on research, and are at an appropriate level given the importance of the functions that peer review fulfils. Nevertheless, the costs are high enough to demand that significant attention should be paid to ensuring that the expenditure of time and effort is both efficient and cost-effective.

That is especially the case since this expenditure of time, cash and other resources brings with it another cost, in terms of delays in publishing the results of research once it has been completed. Such delays are an inevitable consequence of the time taken for reviewers to complete effective reviews, and for authors to respond to them. But the delays can be especially significant and/or irksome when papers are submitted to two or more journals in sequence, which typically leads to more reviews, and thus additional burdens on reviewers. This has led some journals and publishers to introduce procedures under which reviews can be transferred from one journal to another. More radically, some commentators suggest that rapid publication, followed by post-publication review, should become more of a norm (see Section 8).

Unfairness and bias

There have for long been complaints that peer review can be unfair. In the common system where both editors and reviewers know the identity of the authors ('single-blind' review),

there is scope for knowing or unknowing bias on grounds of sex, race, nationality, or field of study. It is clear that this has been and remains an important issue, and publishers have taken a number of steps to reduce the scope for such unfairness.

Even worse are the cases where reviewers act unethically, by failing to disclose a conflict of interest which should preclude them from reviewing a paper, making use of confidential information or ideas for their own purposes, engaging in unfair or *ad hominem* criticism, or delaying a review so that their own work can achieve precedence. The Committee on Publication Ethics (COPE: http://publicationethics.org/) has produced guidance and a wide range of materials for editors and publishers on the action they should take where they suspect activity of this kind, or where suspicions are reported to them.

More generally, responses to the evidence of unfairness and bias has been to move in two different directions: either to institute, or at least allow authors to opt for, double-blind review, where neither reviewers' nor authors' identities are revealed; or to move to various forms of open review, where the identities of both reviewers and authors are made known. We consider the issues of transparency and openness in Section 6.

Publication bias

It is often suggested that peer review introduces a systematic bias into the overall profile of what gets published, which results in gaps in the published records of science. There are thus concerns that it is difficult to publish papers reporting negative results, or results that replicate or confirm findings from previous publications. This difficulty is associated, of course, with the pressure that researchers experience to publish papers in high-status journals, where editors and reviewers are looking for papers that report findings of broad significance and originality. The growth of the so-called mega-journals, where the sole criterion for publication is the soundness of the research, is in part a response to these concerns.

A rather different concern is that peer review tends to inherent conservative judgements and suspicion of unusual research and unexpected results. It is of course proper, as the Royal Society has put it, that extraordinary claims should require extraordinary evidence (Science and Technology Committee 2011); and it is right that journals should seek to publish only those papers that are robust and properly tested. But it is also important that journals should publish research in new and unusual areas.

A related concern arises with regard to interdisciplinary or multidisciplinary research, where it may be difficult to find reviewers with the appropriate expertise to review papers. Many journals thus have a policy of increasing the number of reviewers for multidisciplinary papers, in order to achieve a broad perspective; but many researchers suspect that multidisciplinary work is subject to unduly critical review, or even to a kind of double-jeopardy, where papers have to satisfy the demands of reviewers from two or more

different disciplines who may fail to recognise the significance of what has been achieved in multidisciplinary fashion.

Subversions of the peer review system

In some recent high-profile cases, journals have had to retract papers because researchers have exploited flaws in publishers' editorial systems so that bogus reviews have been submitted by friends and colleagues. Many different publishers have been affected by such scams, and there are now general moves to improve the security of their systems, and to enhance the checks made in the selection of reviewers. Some publishers have removed the facility from their systems that allows authors to make their own suggestions as to peers who might review their papers, although others have retained such facilities, while enhancing their checks on such nominations before anyone is chosen to provide a review. Given the incentives and the pressure on researchers to publish in high status journals, it is important that editors and publishers should continue to be vigilant in seeking to prevent fraud in the form of bogus or conflicted reviews, which threaten the basis of trust on which scholarly publishing is founded.

6. Types of peer review

There are many variations in the ways in which peer review is actually conducted, and publishers and others are engaging in experiments to introduce new variants. It is important that such experimentation should continue, since although most researchers are generally satisfied with the peer review system used by journals, most of them also want to see improvements: the 2009 survey found that only 32% of researchers believe that the system is the best we can achieve, and only slightly fewer (30%) believe that the system 'needs a complete overhaul' (Mulligan 2012).

Identifying reviewers and authors

One of the main areas of difference is the extent to which the identities of reviewers and authors are revealed. There are three main variants:

- ❑ Single-blind review, where authors' names and institutions are revealed to reviewers, but reviewers' names are not revealed to authors. This is the most common approach, particularly in the sciences. The anonymity of the reviewers is thought to encourage forthright reviews, and to give confidence to junior referees in reviewing papers from senior peers. But it secures the confidence of fewer than half of researchers according to the 2009 survey. Many express concern that anonymity for reviewers allows them to behave inappropriately or unethically (see Section 5), to provide rude or unconstructive comments, or simply to do a substandard job (Nuffield Council on Bioethics, 2014). Fundamentally, critics argue that it is wrong for reviewers not to take full responsibility their reviews and critiques by revealing their identities.

❑ Double-blind review, where authors' names are not revealed to reviewers, and vice versa. This approach is more common in the social sciences and humanities, but it is the one in which researchers in all disciplines in the 2009 survey expressed the most confidence. Anonymity on both sides is thought both to encourage forthright reviews and to eliminate many of the opportunities for bias. Nature Publishing Group announced in February plans to allow authors to opt for double-blind review across all the monthly Nature research journals[5], and cited their own surveys confirming that double-blind review is a popular option, along with concerns expressed to editors that single-blind review is prey to bias. On the other hand, many publishers - including Nature Publishing Group - as well as researchers suggest that it is often in practice difficult for authors effectively to hide their identities: citations, subject-matter or style will give the game away. And yet others suggest that it is important for reviewers to know whose work they are assessing, since it enables them to understand it better, and helps in checking against plagiarism.

❑ Open review, where both authors' and reviewers' names are revealed to each other. This was introduced by the *BMJ* in 1999, but it is still at present the least common approach; and in the 2009 survey, it was the one in which researchers expressed least confidence. The survey also indicates that half or more of researchers were less likely to accept invitations to review if their names were revealed. As *Nature* suggests in its editorial of 18 February 2015, 'views about open peer review are probably still evolving' (*Nature* 2015). Its proponents suggest that open review encourages reviewers to be more honest and thoughtful, and to avoid rude and unconstructive comments. Critics, on the other hand, suggest that it means that reviewers are less candid or critical, and that it discourages junior reviewers who may be unwilling to criticise senior and eminent colleagues if their names are revealed. It is notable that in journals where reviewers are given the choice whether to reveal their names, many choose not to do so. And the new journal *PeerJ* has found that while 50% of reviewers who recommend acceptance are prepared to reveal their names, only around 14% of those who recommend rejection are prepared to do so (*PeerJ* 2014). A clear majority of the publishers we spoke to nevertheless indicated that they expected to see more openness in the next few years; but they also pointed to the need to take their research communities with them. Several suggested to us that while researchers in some subjects and disciplines (many areas of medicine, for example) were ready to embrace openness, others were much less ready to do so.

Interaction between reviewers and authors

New technologies have enabled some journals to make the whole peer review process more open and interactive than it was in the past. The journals published by the relatively new

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[5] Two Nature journals – Nature Geoscience and Nature Climate Change – have invited authors to opt for double-bind review since June 2013, but take-up so far has been relatively low: nor more than a fifth of monthly submissions

publisher Frontiers, for example, operate a two-stage review process. The first works in a fairly standard way, with editors passing submitted papers to invited reviewers who submit independent reports. In the second stage, however, authors participate in an online discussion with reviewers (who remain anonymous). The interactive review forum is moderated by editors, and the discussion continues until the reviewers reach a unanimous decision to accept or reject the paper for publication.

The new journal *eLife* has introduced a similar kind of discussion forum for reviewers, who again submit their reviews in the normal way, but then engage in a collective dialogue with an editor about their reviews (which are revealed to each other) in order to reach an agreed view. Experience to date has been that the dialogue has been fruitful: reviewers have changed their minds in the light of their discussions and of the other reviews. The process thus brings benefits both to the reviewers (who gain valuable experience through the discussions) and to authors (who receive a single consolidated list of comments on their papers).

Other publishers have indicated to us that they wish to move in these kinds of directions, in order to make the whole review process much more of an interactive discussion between authors, reviewers and editors. Traditional editorial management systems are not especially well-suited to such developments; but many publishers are keen to exploit the potential of newer systems to encourage more dialogue and discussion, even extending to the post-publication phase (see Section 8).

Publishing reviews

A further move towards transparency and openness is to publish alongside published papers the reviews and the responses to them from authors. Readers can thus see the dialogue between reviewers and authors, and the story of how a paper came to be in its final published form. This can provide valuable contextual information to readers about the paper.

Many of the BioMedCentral journals now owned by Springer have operated in this way since 2000, and the *EMBO Journal* since 2010; and other publishers including BMJ, SAGE, and Elsevier are now introducing pilots and experiments of this kind, including in some cases correspondence between editors and reviewers and authors. Some note, however, that they see little evidence of demand for this kind of service. And while the proponents of openness and transparency suggest that revealing the pre-publication history in this way promotes honesty and thoroughness among reviewers, some are more wary of the implications of such openness. It should also be noted that making the reviews and the pre-publication history accessible to readers does not necessarily imply revealing the names of reviewers (although this happens in most cases, in the *EMBO Journal*, for example, names are not revealed); and that some of the newer journals – including for example *PeerJ* – as well as some of the pilots under way in this area allow authors to choose whether the pre-publication history of their paper should be revealed.

Pre-prints and open peer review

Since 1991, ArXiv has acted as a repository for pre-prints of papers in physics, astronomy, mathematics and some other subjects. It enables researchers to publish papers quickly, and to receive feedback on them. Many of the papers in areas such as high-energy physics are the result of large-scale international collaborations, and are subject to internal peer review before posting. ArXiv now holds over a million papers, with submissions running at 8,000 a month. Most, but not all, of the papers are subsequently submitted to journals for formal publication, and undergo a normal peer review process. This system is well-established and well-understood in the physics community. But there is much debate about whether it can be extended to other areas such as the medical and life sciences, where flawed research and inaccurate interpretations can cause real harm[6] .

But some new journals in these areas have established a controlled variant of the system. Thus *Atmospheric Chemistry and Physics (ACP)*, published by the European Geosciences Union, operates a two-stage publication process. In stage one, papers that pass basic checks are published on a *Discussions* (ACPD) website, where they are subject to public discussion, during which comments from anonymous and named reviewers, and other named members of the scientific community are published, along with authors' responses. In stage two, the peer review process is completed, and accepted papers are published in ACP. Both versions of the paper are citeable and permanently archived. A similar system is used by journals published by Copernicus Publications.

PeerJ operates a similar system. Again, pre-prints are posted after basic quality checks on *PeerJ PrePrints*, where authors can solicit feedback and work on revisions of their paper. Once they are ready, they can then submit the paper to *PeerJ*, where editors select at least two reviewers who review the paper in the normal way. Reviewers can choose whether or not to reveal their names to authors (40% do so); and authors can choose whether or not the reviews should be published (80% do so). Where reviews are made public, they are assigned a DOI.

F1000Research operates similarly, but with the significant difference that versions of papers as submitted and after peer review appear on the same site. Papers again undergo a rapid initial check by an in-house editorial team before being published on the *F1000Research* platform with the status 'awaiting peer review'. Authors are asked to suggest five potential referees with suitable levels of expertise and experience, and with no conflicts of interest. Reviewers are asked to assess whether the research is scientifically sound, and to assign it a status as 'approved', 'approved with reservations' , or 'not approved'. The status is shown on the *F1000Research* platform, along with the review reports. Papers can then be amended in response to the reports, and reviewers are invited to provide additional reports on the new version. All versions of the paper and all reports are freely accessible, and once an

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[6] See the evidence on this point presented to the House of Commons Science and Technology Committee in 2011, summarized in its Report on *Peer Review in Scientific Publications* at paras 66-72

article has received at least two 'approved' statuses, or one 'approved' and two 'approved with reservations' statuses, it is indexed in bibliographic databases such as PubMed. Once an article is indexed, all versions, along with any associated data sets and referee reports, are deposited in PubMed Central. Some of the publishers we interviewed expressed unease about publishing operations of this kind, on the grounds that the status of an article might not be clear to all readers

Cascading or portable reviews

The publishers we interviewed all talked about the need to reduce the redundancy of effort involved in successive reviews of the same paper as authors submit to a second or third journal after rejection by their first choice. Most publishers now offer authors the option to allow the reviews commissioned by one of their journals to be passed on to another; and they are keen to do more of this. This can be attractive to authors who may decide that a rapid decision from another journal in the publisher's stable is preferable to taking a chance with a new submission elsewhere. It is important, however, that authors should be offered the choice, not least because their second choice journal might be with another publisher. Publishers also encounter resistance from some editors, whose independence they value and seek to sustain, and who themselves value the control they have over the processes that lead to decisions on whether or not to publish a paper. They may thus be wary about basing their decisions on reviews that may not take account of the specific nature and scope of their particular journal, with the result that they seek additional reviews. Publishers for their part are cautious about trespassing too far on the independence of their editors.

There have been relatively few attempts so far to establish mechanisms to transfer reviews from one *publisher* to another. There are both commercial and practical reasons for this. As one publisher put it to us 'why would I want to transfer an author, and the work we have put into a paper, to another publisher?'. Others suggested, however, that such transfers reflected credit on the publisher as a good citizen. But even when they are willing to make reviews portable in this way, publishers find practical difficulties, since it typically involves manual intervention in their editorial management systems on the part of both the exporting and the receiving publisher. The most notable example of a cross-publisher transfer alliance is the Neuroscience Peer Review Consortium (nprc.incf.org) which covers some forty journals which have agreed to forward all reviews upon authors' request, and to inform reviewers (named or anonymous) that their reviews may be forwarded. Publishers with journals in the consortium tell us, however, that take-up is small.

7. Reproducibility, reliability and data

As we noted in Section 3, reproducibility is often mentioned as a key goal in ensuring that science can progress effectively. For as Karl Popper noted, 'non-reproducible single occurrences are of no significance to science'. But as we noted earlier, evidence suggests that only a relatively small proportion of the studies reported in journal articles in the biosciences are in fact reproducible. There is burgeoning discussion around the issues of reproducibility

(which is not always achievable in all subjects, disciplines and kinds of research), replicability and reliability; and some publishers have begun to develop checklists to address the issues involved.

There seem to be two key problems here. The first relates to the unprecedented increases in the volumes of data that researchers gather and analyse in the course of their work. Only a very small proportion of that data can be presented within the constraints of a journal article, and many journals are now beginning to address this issue by encouraging or requiring authors to make available via a public repository the data on which their findings rely, and to provide bidirectional links when papers are published. Most of our interviewees, however, recognise that it is unrealistic to expect reviewers at pre-publication stage to examine and assess large volumes of data in significant depth: they simply do not have the time. Although a small number of journals – particularly specialist data journals such as *GigaScience* - may select or recruit (and in one or two cases pay) specialist data or informatics reviewers, any problems relating to the data are thus more likely to be picked up once a paper has been published (see Section 8).

A similar issue relates to statistical analyses. Although a number of journals and publishers have defined policies relating to such analyses, and guidelines for reviewers on how to review them, one of our publisher interviewees pointed out that there are no industry-wide guidelines, and many journals do not use specialist statistical reviewers. It is perhaps not surprising that studies have revealed numerous papers with statistical errors in data analysis, presentation or interpretation. Steps are now being taken by some journals to address these issues; but there is clearly more to be done at cross-publisher level.

8. Post-publication reviews and comments

In the past few years there has been much discussion about 'post-publication peer review', as either a supplement to or a replacement for pre-publication review. But the phrase has come to mean a number of rather different things, and it is helpful to distinguish between them.

It is sometimes used to cover the kind of publishing services operated by journals and publishers (such as *F100Research* and Copernicus Publications) discussed in Section 6, where reviews are provided by invited reviewers after a pre-print has been published un-reviewed.

It may also cover the systems used by newer and as yet relatively small start-ups such as *Science Open* (www.scienceopen.com)and *The Winnower (*https://thewinnower.com) where papers are again published online before peer review, and anyone who meets certain criteria (a number of articles in their ORCID profile, or simply registration on the site) can post a review. Such systems represent the most radical end to date of the moves towards openness, and of the aims of those who urge that we should move from a 'filter then publish' to a 'publish then filter' model; but they have not as yet secured wide take-up, and they are subject to the kinds of criticisms noted earlier about putting non-reviewed papers into the

public domain. Moreover, a low level of responses from uninvited reviewers has meant that many papers have remained effectively un-reviewed.

Comments and ratings

More generally, however, post-publication review is used to cover a wide range of comments and ratings of papers that have been published after undergoing pre-publication review. These ratings and comments may be on the publisher's site, alongside the article, or on social media and a wide range of third party sites. Post-publication comments have of course been a feature of scholarly publishing for many years, via letters to the editor, rapid responses, review articles and so on, as well as subsequent research articles in the same field. Such processes are in general mediated by editors and publishers. But the web now provides a multiplicity of sources and platforms for usually-unmediated comments.

When *PLOS ONE* was launched in 2006, one of its significant innovations was to provide features to allow readers to comment on and rate papers. Take-up has been modest, however, probably because researchers have few incentives to engage; and where other publishers, including the Royal Society, have followed suit, most of them have similarly encountered low levels of interest. The BMJ Group seems to be exceptional in finding extensive use of its rapid response and e-letters systems.

A more formal kind of mediated service is provided by *F1000Prime*, which uses a network of six thousand expert members to provide ratings and short evaluations, in order to highlight important articles – irrespective of where they are published - as a service to the life sciences research community. Many members review individual articles, and authors can write comments in response. The service is restricted to biology and medicine, and we are not aware of similar services being developed in other areas.

But informal and unmediated commenting on recent publications via blogs and twitter, and the sharing of links to important articles, have been common features of the scholarly communications landscape for several years now; and they have proved useful in quickly exposing flaws in published articles (and thus failings in pre-publication peer review), in notable cases such as Hwang Woo-suk's falsification of data. More positively, the rise of open reference management systems such as Mendeley and Zotero, and of sharing sites such as Research Gate and Academia.edu, has allowed researchers to share their reference lists and bibliographies. And more recently we have seen the growth of more than twenty platforms, from annotatr (http://annotatr.appspot.com/) , through Epistemio (http://www.epistemio.com/) and PaperCritic (http://www.papercritic.com/) to PeerLibrary (https://peerlibrary.org/) where researchers can write and read reviews of published papers.

Much of the recent commentary has focused on these new 'online journal clubs' specifically-designed to allow researchers to comment on recently-published articles. One of the most prominent is PubPeer (https://pubpeer.com/), which allows anyone with a previous

publication and an email address at an academic or research institution to comment or ask a question about a paper. Comments are anonymous by default, but PubPeer contacts authors when comments are posted about their papers. The site played a prominent role in exposing two papers by Haruko Obokata of the Riken Center for Developmental Biology in Japan, published by *Nature* and subsequently retracted. A similarly high-profile site is PubMed Commons (http://www.ncbi.nlm.nih.gov/pubmedcommons/), a platform established by PubMed which invites authors with at least one paper in PubMed to comment on other articles in the database. Unlike PubPeer, comments cannot be anonymous.

The growth of such sites in one sense simply adds to the number of places – alongside blogs, twitter and other social media sites - where post-publication comments can be made; and some commentators have expressed concern that it is becoming too difficult to keep track of them all (which is a problem for publishers as well as readers, since comments do not always provide an easy link back to the published version of the article in the form of a DOI). Others are less worried by the resulting fragmentation of discussions about a paper, while some suggest that we are likely to see some consolidation around the more useful or successful sites, including Research Gate's Open Review tool (http://www.researchgate.net/publicliterature.OpenReviewInfo.html), which encourages more structured and systematic reviews than the simple comments in PubPeer and PubMed Commons. Whether there will eventually be some consolidation of commenting sites and services, or whether they will remain scattered across a multitude of sites and unlinked to the articles on which they comment is as yet unclear. What *is* clear is that, through these new sites, conversations about recently-published articles that until recently tended to take place in private can now engage more people, and to productive effect.

Critiques

These various developments have also, however, given rise to a number of concerns.

- ❑ First, relatively few articles as yet receive comments either on publishers' or on third-party platforms, or via blogs or other social media services, and those that do tend to be the more controversial ones. There are few incentives for researchers to engage in post-publication commenting or review: they are busy doing other things, they receive no credit, and they risk alienating their colleagues. Indeed, if they have substantive criticisms of a published paper, they might do better to undertake and publish a study to substantiate those criticisms.
- ❑ Second, while some platforms seek to restrict comments to those who have some basic research credentials, there is no effective system to ensure that commenters have relevant expertise in the field of the article on which they are commenting.
- ❑ Third, there appears to be a tendency – particularly on the third party sites - to focus on negative rather than positive comments. There has been particular criticism of the anonymous commenting on the PubPeer site, which critics suggest encourages users to defame and damage the reputation of researchers on whose papers they comment.

PubPeer suggests that loss of anonymity would unfairly stifle critical commentary, and that in any case, critiques that are unfair or based on misunderstandings are usually subject to ready rejoinder. The site is thus resisting a subpoena to reveal the identities of those whose comments on a published paper are alleged to have led to the withdrawal of a job offer in the USA. Similar legal problems led to the closure of the Science Fraud site in 2013.

Post-publication metrics

Despite the problems noted above, there has been increasing interest in the use of measures which seek to aggregate evidence of activity relating to an article once it has been published. The evidence can take the form of comments and ratings on the journal site, mentions in blogs and on social media sites, bookmarking on social reference management sites, mentions in news stories and so on, as well as reviews and comments on third party platforms of the kind outlined above. Evidence of such activity can be aggregated in the form of 'altmetrics', and also combined with usage data such as views and downloads, and with citation data, to produce article-level metrics which measure an article's impact. Services currently available include altmetric (http://www.altmetric.com/) , Plum Analytics (www.plumanalytics.com), and Impact Story (https://impactstory.org/).

These services are becoming more complex and sophisticated in the kinds of data they gather, and are likely to become more integrated with the kinds of citation measurement services provided by Thomson Reuters and Elsevier, as well as with the metrics offered by Google Scholar.

Publishers and post-publication review

Most publishers see post-publication review, comments, ratings and metrics as an increasingly important supplement to, but not a replacement for, pre-publication peer review. Many of them are providing links to comments and ratings on third party sites when they can readily do so, and are engaging with services such as altmetrics to provide alongside the article itself evidence of relevant post-publication activity and impact. Some of our interviewees expect to see over the next few years much greater efforts at integration and dialogue between authors, editors and pre-publication reviewers on the one hand, and post-publication commenters and raters on the other. This will require considerable investment in new systems. Our interviewees were clear that post-publication activity of the kind we have outlined in this section will thus develop further to serve as an increasingly important element in reviewing and assessing the quality and impact of the papers they publish.

9. Training, guidance and quality of reviews

It is clearly important that editors and reviewers should have the right skills for the job. Publishers are conscious, through the monitoring that they and their editors undertake, of the efforts needed to recruit good reviewers, and of significant variations in the quality of

the reviews they receive from the reviewers they select. They are thus increasingly engaged in efforts to increase capacity and enhance capabilities in peer review, since it is such a critical part of their business.

Training for editors takes a number of forms. Many publishers provide information packs and guidance notes for new editors, along with workshops and training provided by in-house staff and by experienced editors. Publishers including PLOS, BMJ Group and Elsevier are also making use of videos and online courses and discussion forums for editors.

Training for reviewers tends to be rather less structured, although some of our interviewees suggested that at least some of the training they provide for editors does get passed on to reviewers. Most but by no means all journals and publishers require editors to provide feedback to reviewers; but in some cases reviewers do not even receive notice of the fate of the papers they have reviewed. More positively, the interaction between editors and the reviewers of individual papers instituted by *eLife* seems to have been particularly valuable as feedback. A number of publishers, including Elsevier, Wiley and IoP Publishing, have also introduced workshops, webinars and mentoring programmes for early-career researchers, to introduce them to the key features of refereeing and peer review. In some cases publishers have moved towards certification for those who complete such programmes satisfactorily.

A more informal kind of training takes place when senior reviewers ask junior colleagues to participate when they are invited to review a paper. Some publishers told us that they encourage this, so long as it is done transparently, and both reviewers sign the review report. Practice of this kind can provide a valuable introduction to the peer review process for early career researchers (who may also benefit through advertising their availability via the Academic Karma service; see Section 10) . Other publishers told us, however, of differences of view among their editors with regard to reviewing of this kind, and of unethical practice they had discovered when senior researchers had in effect delegated the review to a junior colleague but not informed the editor that s/he had done so.

The general view among our interviewees was that they wished, and in some cases had plans, to do more in the way of training for both editors and reviewers. They were for the most part unclear, however, as to the relationship between what they could or should be doing in this area and the roles and responsibilities of research funders and institutions in providing general training for PhD students and early-career researchers (House of Commons Science and Technology Committee, 2011).

10. Rewards for reviewers

Reviewing is typically regarded as an integral part of researchers' professional lives, and in some senses a reciprocal service for the benefits they receive when their own papers are reviewed. But the scholarly credit they receive for their work as reviewers tends to be much less direct than that they receive when they publish papers. Many journals and publishers

produce annual lists of those who have reviewed for them; and some provide discounts towards subscriptions or APCs for open access articles, gifts of books and so on. How much effective credit or reward reviewers receive through such mechanisms is not, however, very clear.

Most of our interviewees expressed the wish to do more in the way of assigning credit for reviews; but they were at best cautious about offering more in the way of payments or other monetary rewards, for two main reasons. First, they were aware that it would imply a substantial increase in costs: any benefit reviewers and their employing institutions received in the form of payments for peer review would lead to an increase in what they paid for subscriptions and in APCs. Second, and more substantively, they were concerned about the implications of putting a price on the services that reviewers provide, and the risks that could bring to the relationships between reviewers, editors and authors. The open access journal *Collabra* (http://collabraoa.org/), recently launched by the University of California Press, nevertheless has a business model that includes provision for payments to editors and reviewers, and some of our interviewees suggested that they would keep a close eye on how that develops.[7]

But all the publishers we spoke to wanted to see more scholarly credit attached to the work involved in producing a high-quality review, and to make the results of this work more visible. This is in part a response to concerns about increasing difficulties in enlisting well-qualified reviewers. Thus Elsevier has a pilot system to award digital badges to reviewers, and a reviewer recognition platform where reviewers have personal pages which outlines all their reviewing activity; while other publishers including Wiley are seeking to secure a better understanding of the kinds of scholarly incentives that underlie decisions to accept invitations to review, and how publishers might enhance those incentives.

Some see open reviews published along with the article as being key here, since such reviews are in the public domain and can be added to personal bibliographies. Some publishers are now proposing to follow *PeerJ* in assigning DOIs to such reviews, along with ORCID identifiers for the reviewers, so that the reviews can more easily be cited. And several publishers have also been in discussions with Publons (https://publons.com/), a new service which aims to aggregate information about reviews (pre-publication and post-publication) to produce reviewer profiles. Reviewers themselves can control how each review is displayed in their Publons profile, and thus include both open and blind reviews. Some of our interviewees were concerned that the service seemed to focus on the volume rather than the quality of review; and about possible ethical issues in reviewers' deciding to make data about reviews (and even reviews themselves) accessible when they had been commissioned and written on a different basis. And as another pointed out, it is not yet clear how members of the research community will respond to this service: as in many of the

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[7] The model assumes, however, that many of the fees will be donated back to the journal to fund its activities.

other areas we have discussed in this report, success will depend on the extent to which researchers see tangible value arising as a result of their participation in such a service.

A rather different kind of approach is being promoted by the Academic Karma (http://academickarma.org/) platform developed in Australia, which provides a platform for writing and submitting reviews, customised to meet the varying requirements of different journals. The platform enables researchers to construct a profile of their reviewing activity, linked to their ORCID profile, and to achieve a score based on the reviews they have submitted, minus the number they have received (assuming three reviews for each article they have published, divided by the number of authors for each article). Since researchers can also effectively use their profiles to advertise their availability for peer review, the service also aims to speed up the process, by enabling editors to view and contact reviewers who may be particularly appropriate for particular papers. This may also have the effect of alerting editors to the availability of early-career researchers of whom they might not otherwise be aware.

11. Independent peer review platforms

A significant development in the past two years has been the emergence of platforms that provide a pre-publication peer review service independent of journals. The most prominent of these are Rubriq (http://www.rubriq.com/) , launched by Research Square, a US company which has developed various services to give expert advice to researchers on key aspects of the publication process, including the selection of journals in which to publish; editage (https://www.editage.com/publication-support/) which again provides peer review services alongside a wider range of publication support services; Axios review (http://axiosreview.org/) which provides peer review services with links to journals in biology and ecology; and Peerage of Science (https://www.peerageofscience.org/), which also provides peer review services in similar subject areas.

Rubriq and the peer review services provided by Editage may be seen in one sense as a natural extension of the specialist editorial services the relevant companies have been offering for some years to help researchers ensure that their papers are in good shape for submission to a journal. From the perspective of authors, they provide – in return for payment of a fee - review reports that are independent of any particular journal or publisher, and which enable them to enhance the chances that a particular paper will be accepted by a journal. The Editage services extend to support in submitting and resubmitting papers to journals, while the Rubriq service also extends to advice on the journals which provide the best fit for the paper. It also offers a service to publishers and journal editors in the form of access to scorecards and assessments that at the least help in the initial triage stage of review, when decisions are made about which papers to send for full peer review.

Axios review operates in similar ways in the areas of evolutionary or ecological research. Authors submit papers along with a list of four target journals. Reviewers assess the quality

of the paper and also its suitability for each of the target journals. The paper is then sent to the first-ranked appropriate journal along with the reviewers' reports, in what amounts to a pre-submission enquiry. If it is accepted - if necessary after revision - the authors are charged a fee (currently $250). Axios has a target list of some fifty journals which have indicated that they are happy to receive referrals; and some of the open access journals subtract the Axios author fee from their standard article processing charge.

Peerage of Science offers a more complex service which aims not only to provide for authors reviews that are independent of journals, but to improve both the speed and the quality of reviews, and to provide credit to reviewers. It is based around a group of peers in biology and ecology, currently 1700 in number. When authors submit a paper, a four-stage review process is initiated, each with a deadline set by the authors. Peers volunteer to submit in a standardised format anonymous reviews which are accessible to authors. The individual reviews are then evaluated by each reviewer, and given a quality score, before in the third stage, authors revise their manuscript in response to the reviews (taking account of the scores given to each review). Finally, the revised papers are evaluated by the reviewers, and given a quality rating.

As with the other third party services, Peerage of Science reviews can be made accessible to publishers. But a key feature from the perspective of publishers and editors is that journals that sign up to a full 'select' service receive alerts as soon as a paper is submitted, can follow the four stages of the process, and can offer to accept the manuscript for publication at any stage once reviews have been completed. For journals and publishers that join a 'connect' service, clickable links are displayed in the authors' export tool once the review process is complete, so that they can make the paper and the reviews accessible to editors[8]. Finally, the benefit for reviewers is that they receive immediate feedback on the reviews they have submitted, as well as credit in the form of ratings for their work.

A rather different kind of approach has been adopted in the Libre service being developed by the Open Scholar organisation (http://www.openscholar.org.uk/open-peer-review/), with an 'author-guided open peer review system' under which authors post their papers on any online service (a pre-print server, repository or similar) and then invite their peers to submit formal evaluations of the work, under the terms of a protocol which requires the reviews and the names of the reviewers to be open. Reviews themselves, along with the original article (and revised versions), are assigned DOIs, with links backwards and forwards.

All of these services are as yet operating on a relatively small scale, and it is far from clear whether platforms of this kind are likely to become a substantial part of the peer review landscape in the next few years. It is perhaps significant that Axios and Peerage of Science both operate in the areas of biology and ecology, and it is not clear whether they can or will eventually expand into other areas. And although a number of journals and publishers

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[8] Springer is the largest publisher that has signed up to the 'connect' service.

(including Springer) have established relationships with such services, our interviewees were all cautious about them, for two main reasons. First, they indicated that while third party review may prove useful for mega-journals where the key criterion for publication is the soundness of the research (rather than its significance, originality or likely impact), for other journals reviews had to be set firmly in the context set by the nature and scope of the journal itself. Second, many of them took the view that peer review was so central to the operations and indeed the purposes of journal publishing that they were concerned to retain direct oversight and control of it, and not to outsource it to a third party. If such doubts persist, it seems likely that while such services may develop niche positions, particularly in the form of reviewing papers before they are submitted to journals, they are unlikely to become major players in the provision of peer review services to journals themselves over the next four-five years. A contrary view is that such services may further stimulate the growth of such mega-journals; and Jan Velterop has recently suggested that they could help dramatically to reduce the costs of publishing, by abstracting from publishers the costs of managing peer review, as in his proposed *Journals of Nature and Science* (JONAS) (Velterop, 2014)

12. Conclusions

Peer review remains a bedrock of the scholarly communications system, from the perspectives of the research community and also of publishers. Our study has revealed a great deal of experimentation in different approaches to peer review, both pre- and post-publication. The experiments and innovations are in part a response to concerns - some long-standing and others that have arisen more recently - about the efficiency, effectiveness and fairness of current systems and approaches; but have also been stimulated by the potential of new technologies, and by new entrants to the market.

Risks and concerns

The key concerns relate to the continuing rise in the volumes of papers being submitted for publication. This rise, however, has been in evidence at least since the Second World War, and appears to be closely correlated with increases in the number of active researchers worldwide. The implication is that the rise in the number of papers has been accompanied by a rise also in the number of peers qualified to review them. But many of our interviewees spoke also of their concerns about a further ratcheting-up of the 'publish or perish' pressure on researchers , especially the pressure to secure publication in high-status journals; and the recent survey evidence from the Nuffield Council on Bioethics tends to support the view that researchers are feeling an increases in these pressures. This in turn increases the incentives for researchers to cut corners and to engage in misconduct of various kinds, both in the course of their research and when submitting papers for publication.

The pressure is then passed on to publishers and editors who must seek to ensure that their peer review and other quality assurance checks (including, for instance checks against

plagiarism and image manipulation) act as effective filters against the publication of work that involves misconduct or fraud. They therefore worry about difficulties in recruiting high-quality reviewers; about the need to avoid overloading them; about the need to provide them with effective support, guidance and training; and about the risks to the reputation of their journals – and even to the scholarly publishing system as a whole – when pre-publication review and other checks fail to detect major problems with papers.

But there are risks in the opposite direction too. Publishers and editors want to ensure that good work *does* get published, and that it is published in the best form that it can be. But many of our interviewees spoke also of over-critical and purely negative reviews, and of the need to rein in reviewers who make unreasonable demands on authors, or set impossible standards, especially in new and fast-moving fields. Some therefore suggested that there was a need to urge editors to exert greater influence over reviewers, with the aim of encouraging them to submit constructive and supportive, rather than negative, reviews.

Achieving an appropriate balance in all cases between properly rigorous review on the one hand and unduly critical reviews on the other is difficult; and publishers and editors are taking various steps to enhance their ability to achieve it, particularly in the areas we discuss below.

Opportunities and likely developments

All of our interviewees talked about an increasing pace of experimentation and change, with established approaches and models enhance and supplemented by newer ones. Some also suggested that there should be more sharing of results between publishers. We highlight below six key areas of likely development.

First, openness and transparency. Despite the evidence of caution or even reluctance from members of the research community, our interviewees all spoke of the need to move towards greater transparency and openness in the review process. But there is a clear distinction to be made between openness in terms of revealing *reviewers' identities* on the one hand, and revealing the *content of reviews* to readers as well as authors on the other. At least in some subject communities, the former is likely to be less acceptable, at least in the short term, than the latter.

Second, there is also common agreement on the desirability of more interaction between editors, reviewers and authors, though some editorial management systems are not especially well-adapted to facilitating such interaction. Newer 'end-to-end' submission to publication systems should ease some of those constraints. More ambitious would be systems to facilitate dialogue not just between all those involved in pre-publication review, but also with those engaged in post-publication comments, reviews and ratings. Most of the larger publishers already seek to provide links on their platforms to post-publication activity. But it can be difficult to keep track of all the activity on a multiplicity of sites, especially when the relevant DOI is not cited in all cases. But even when links *are* provided

at present, there is little interaction, since the pre and post-publication activities happen independently of each other. There is much to be said for joining them up, either via the publisher platform or through some other social media or other platform, provided that so doing does not add significantly to the burdens on editors and reviewers.

Third, article-level metrics. *PLOSONE* was the pioneer here, and other publishers have been keen to provide similar kinds of service. The metrics now go beyond the traditional views, downloads and citations to include - with the help of services such as Altmetric, Plum Analytics, and Impact Story - a range of metrics relating to comments and ratings, mentions in social media and news sites, bookmarking and so on. There is still debate about how the metrics are generated, the weightings attached to different measures and the extent to which they are aggregated, and so on. But they are going to be an increasingly important feature of scholarly publishing. Many publishers as well as researchers hope that they will come to diminish the importance of, or even to supplant, the baleful influence of journal impact factors.

Fourth, there will be increasing interest in the provision of rewards in the form of scholarly credit, recognition and accreditation for reviewers. There seem to be differences of view in the research community as to the credit that either can or should be attached to a peer review report. Some commentators suggest that they either can or do represent valuable additions to a CV; others are more sceptical. But publishers as well as start-ups such as Publons and Peerage of Science are keen to do more to ensure that proper credit is given for the valuable contributions that reviewers make to scholarly communications and to the research community as a whole. There is little enthusiasm – rather the reverse – for any suggestion of monetary rewards other than in indirect form such as discounts for subscriptions or article processing charges. But recognition not just of the quantity but also the quality of reviews, whether via publisher-specific or third-party aggregator sites seems likely to be an increasingly-significant part of the landscape over the next two-three years. The development of the third party sites in particular will depend on the extent to which they achieve acceptance and take-up by researchers working in a wide range of subject areas.

Fifth, there will be continuing efforts to improve guidance, training and feedback for reviewers; and assessment and ratings of reviews and reviewers. The importance of these was highlighted in the House of Commons Science and Technology Committee's report in 2011; publishers have already started to make improvements, and more are planned. They are essential if the peer review system is to sustain the confidence of the research community.

Sixth, we are likely to see increasing differentiation between the distinct but related purposes of peer review. The distinctions are sometimes blurred, and often not as clear-cut as some commentators suggest. Assessment of the significance or likely impact of a paper cannot always readily be distinguished from the soundness of the research on which it is

based. But the rise of the mega-journals has highlighted the usefulness of at least seeking to distinguish between whether the research on which a paper is based is sound and thus worthy of publication, and whether it fits with the nature, scope and ambitions of the journal to which it has been submitted. Not least, such a distinction can be used to reduce the redundancy of effort involved when papers are submitted successively to more than one journal. Publishers are making increasing use of 'cascade' systems to avoid reviewing papers more than is necessary, and they are keen to do more, so long as they can secure the support of editors. Whether there is more scope for transferring reviews between publishers, or whether independent third-party review services will increase in role and scope, is not yet clear.

Marching with the research community

There are many vocal critics of and commentators on current approaches to peer review, and advocates for new systems and approaches. But all our interviewees spoke of the need not to get too far in advance of the different subject communities they serve. The cultures of those communities are very powerful, and for obvious reasons journals and publishers are keen to avoid the risk of alienating key sections of them. That is why many experiments and innovations, even from the newer entrants to the market, are introduced as pilots and/or on an optional basis; and why we are unlikely to see widespread abandonment, for example, of pre-publication in favour of post-publication review. Editors play a key role here, and publishers rely on them for advice on what is or might not be acceptable. Their role is likely to be enhanced as the pace of experiment and innovation quickens.

More broadly, however, we detect a sense in which while publishers will continue to explore new approaches in the ways we have described, they would welcome more guidance from key sections of the research community on the kinds of peer review services they want from publishers, and on the purposes that they should seek to fulfil. Unless the purposes are defined with greater clarity than they are at present, at least some of the current experimentation may prove to be of little point.

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