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Peer Review
An Introduction and Guide

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1. What is peer review?

Editorial peer review is the process of subjecting an author's scholarly manuscript to the scrutiny of others who are experts in the same field, prior to publication in a journal.

There are other kinds of peer review that we shall not cover in this guide, notably the review of researchers' grant proposals, as well as engineering technical review, software peer review, and so on. We shall use "peer review" simply to mean editorial peer review, unless otherwise specified.

The purpose of peer review is to assess the quality of research prior to publication. It typically checks work for validity (or technical soundness), significance and originality of the research, as well as for clarity of expression. The first of these criteria is fundamental to all peer review, with the relative emphasis placed on the remaining factors varying according to the journal conducting the review and its intended audience. As we shall see, peer review does not just assess the quality of research, but the process also improves the quality of the published paper, that is, it enhances the communication of the research.

1.1. Scholarly communication and the research cycle

Because peer review is a core part of the scholarly journal, it needs to be understood as part of the journal system, which in turn is part of the wider system of scholarly communication.

Science (and scholarship more generally) progress through the discovery and sharing of new findings. Researchers develop their understanding of a field through the study of previously published research, allowing them to identify unanswered questions or new areas of study. They then carry out research to test these new hypotheses, and share their findings with the community through publication, referencing the earlier work to build on what is already known. This process of studying the literature, idea discovery and hypothesis generation, gaining funding or approvals for research, conducting the research, and disseminating the results, which in turn feeds back into new idea discovery and hence starts the process over again, is known as the research cycle. Peer reviewed journals play an important role in all stages of this cycle, particularly of course in the initial idea generation and final dissemination stages, but also in supporting roles during the stages of grant proposal (literature reviews) and conducting research (awareness and validation).

1.2. The journal

Within the scholarly communication system the journal's role is substantially wider and more important than just the dissemination (or "publication") of results. Its functions are usually seen as follows:

- *Registration*: the third-party recording of the author's precedence and ownership of an idea
- *Certification*: providing quality control and establishing the validity of a scholarly claim through peer review
- *Dissemination* or *Awareness*: communicating the findings to the intended audience (e.g. via the brand identity of the journal)
- *Archiving*: the preservation of the scholarly record over time
- *Rewarding*: participants (primarily authors) are rewarded for their performance based on various metrics derived from the scholarly communication system.

There are a large number of journals, with for instance over 28,000 academic peer reviewed journals listed in Ulrich's Directory, collectively publishing some 1.8 million articles a year, and both these numbers grow steadily at about 3–3.5% per year. This covers all areas of scholarship but even within individual specialist disciplines there can be many more journals than an individual

researcher could hope to read, for instance several hundred in neuroscience alone. Although the "article economy" (i.e. the discovery and consumption of individual articles based for instance on keyword searches) is increasingly important, the filtering of articles by journals focussed on defined topics, serving a particular community, and stratified by quality or significance of findings, remains a key way for researchers to manage the otherwise overwhelming volumes of publications.

Publishing in journals is thus an integral part of being a researcher. It connects them to other researchers in their field and keeps them abreast of developments. It allows (at least in principle) work to be repeated and the results tested. It provides a permanent record, sometimes referred to as the "minutes of science", on which future work can reliably be built. Researchers benefit from the promotion and dissemination of their work and gain recognition, credit and funding in the process. Central to all this is the role of peer review in demonstrating the quality of the researcher's work, in terms of its validity, significance and originality, and through the improvements to the communication of research that peer review contributes.

As well as benefiting researchers, peer review also benefits research funders, policy-makers and wider society by giving confidence in the scientific validity of the evidence base that underpins much of policy in a modern society, from the efficacy of drug treatments to dealing with global warming and its consequences.

2. Strengths and weaknesses of peer review

2.1. Benefits of peer review

It's worth looking in a little more detail at the benefits that peer review brings.

There are at least two ways in which peer review raises the quality of published papers: first, simply setting criteria for acceptance motivates authors to improve the quality of their work prior to submission; and second, the feedback that authors receive from reviewers and editors improves the publication through the revision stages.

The evidence for the reality of these improvements is strong: in repeated surveys over 90% of researchers say that the process of peer review has improved not just papers in general but has specifically improved their own last published paper. They report improvements to presentation, language and readability, and also substantive changes such the identification and remedying of scientific or statistical errors, or missing or inaccurate references.

Peer review and the journal system more widely provide an important means of filtering the large (and growing) volumes of research outputs. To start with, review is designed to filter out work that is poorly designed or implemented or otherwise of low soundness, or is unoriginal (whether plagiarised or innocently repeating earlier work), allowing readers to focus just on new work that is technically valid.

Perhaps more importantly for working researchers, the stratification of journals by perceived quality is enabled by the filtering of better papers via peer review to better journals. Researchers are thus able to focus on a manageable number of core journals within their field (perhaps supported by additional alerting mechanisms for relevant articles from other peer reviewed journals outside their core). Peer review also supports this process, at least for some journals, by making relevance to the journal's primary audience a criterion for reviewers.

Peer review also provides a "seal of approval" distinguishing valid science from other published but not peer-reviewed articles and reports. This is crucial for lay readers who are not otherwise competent to distinguish unscientific claims from well-grounded research.

This is also important for researchers who are not specialists in a particular field. This is increasingly often the case as interdisciplinary research becomes the norm, not exclusively but certainly notably

in the "grand challenges" like sustainability and climate change, global food security, disease control, genetics personalised medicine, and so on.

2.2. Critiques of peer review

Peer review is not, however, without its critics. The main charges levelled at it concern its validity, effectiveness, efficiency and fairness – a fairly comprehensive critique! Let's look in turn at the substance of these.

Perhaps the most damning criticism would appear to be that "peer review does not work", that is, that there is an absence of scientifically valid empirical evidence that peer review leads to a higher quality of research. (Note this is different from asserting that it improves research *publications*, which is widely accepted.) The absence of evidence is not the same thing as evidence of absence, of course, and the critics accept that this is both a high hurdle and a question of considerable difficulty to test in the real world.

Various studies have shown peer review indeed lacks effectiveness in some areas. For instance it has been shown to be unreliable (in the sense of two reviewers reliably agreeing about a particular paper), and not very good at detecting errors. It also adds delay to the publication process, arguably slowing down the dissemination and hence progress of science.

It is true that peer review is a "burden" on researchers, in the sense that it represents real work to be done (the annual non-cash cost of the researchers' time involved is estimated to be around £2 billion), but this is generally seen as an appropriate burden for researchers to carry as an integral part of the process of research and their professional status as academics. The evidence for a "crisis" in peer review, with growth in submissions overwhelming the numbers of available researchers is weak. Research outputs are correlated directly with the number of active researchers, so more research outputs also means more potential reviewers. There may, however, be a temporary imbalance, as the rise in peer review experience and capabilities in fast-growing research regions like China and India lags the growth in outputs from these regions.

Peer review is also criticised for its potential unfairness. In the common single-blinded version, reviewers know the identity of the authors but can veil their criticism behind anonymity. This allows scope for bias (e.g. by nationality, language, specialty and perhaps gender) or worse (e.g. reviewer misconduct such as deliberately delaying publication to allow their own work to take precedence). Journals are exploring the increased use of both double-blinded review and of more open review as ways to mitigate these flaws.

All these criticisms need to be understood in a context in which peer review is recognised as an imperfect human activity, and in which there is almost no constituency among active researchers for doing away with peer review. Nonetheless improving the efficiency and effectiveness of a time-consuming and important process is clearly desirable. Some obvious targets include reducing the amount of repeat peer reviewing via multiple sequential submission that is encouraged by the present reward systems, reducing the amount of unnecessary new experiments or other rework demanded by reviewers, and complementing peer review with other metrics to improve overall effectiveness. Journals, publishers and some new players are busy innovating in this area, as we shall see later.

3. Peer review in practice

3.1. The publishing cycle

The movement of information between authors, reviewers, editors and publishers, and then through various intermediaries to readers is sometimes called the *publishing cycle* and can be illustrated in a

simplified form as in Figure 1. We are interested in just the peer review workflow shown in the left-hand part of this diagram.

Peer review workflows vary considerably in the fine detail from journal to journal, but a typical generic approach is shown in outline in Figure 2. The key stages are: submission, initial screening and editorial review, selection of reviewers, receipt and consideration of reviewer reports, first decision made and communicated to authors. It is relatively rare for papers to be accepted without requiring any revisions, so there is usually a further cycle in which the author revises and resubmits, at which point (depending on the extent of the revisions) the paper may be accepted after assessment by the editor, or may be sent out for further review. Some journals may have an appeals process for rejected papers, for instance referring qualifying appeals to a member of the editorial board not involved in the original review. Failing this, authors will often attempt to publish the paper by submitting it to another journal, where the review cycle begins again.

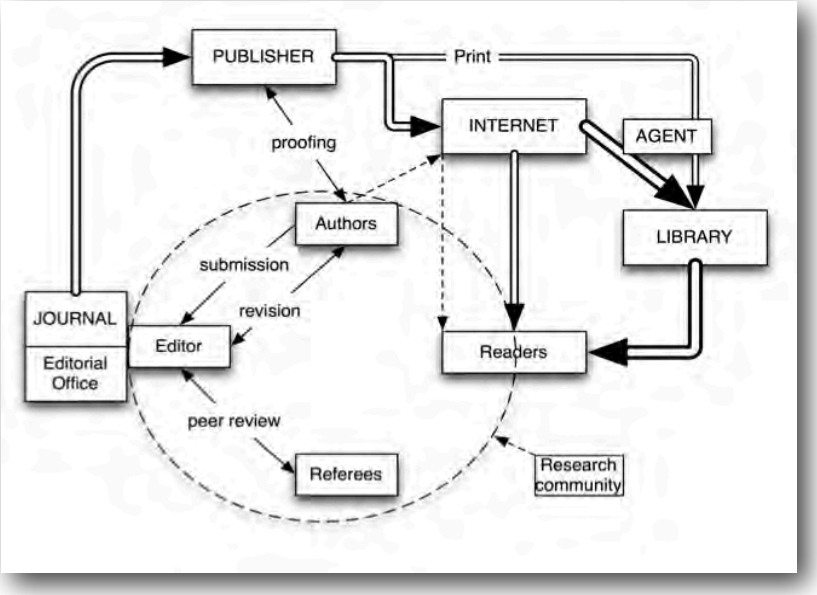


Figure 1: The publishing cycle (from *The STM Report*, used by kind permission of STM)

3.2. Roles in peer review

Before we look in more detail at each stage of this process it would be helpful to describe the different roles in peer review.

Authors

The most important actor is of course the author, or more usually the authors, as co-authorship is the norm for articles in most fields (mathematics and the humanities are partial exceptions, though even here co-authorship is growing). In a multi-author paper, the author who coordinates communication on behalf of the other authors with the journal, publisher and eventually with readers, is known as the *corresponding author*. Authors are expected to adhere to the standards of academic discourse (including avoiding duplicate publication or duplicate submissions), declare all conflicts of interest, obtain all necessary ethical clearances and consents, not present others' work as their own, and to cite relevant prior work. The corresponding author is expected not just to manage correspondence with the journal, but to be responsible for ensuring all authors follow guidelines and abide by the journal's policies. They are also responsible for resolving any inter-author disputes.

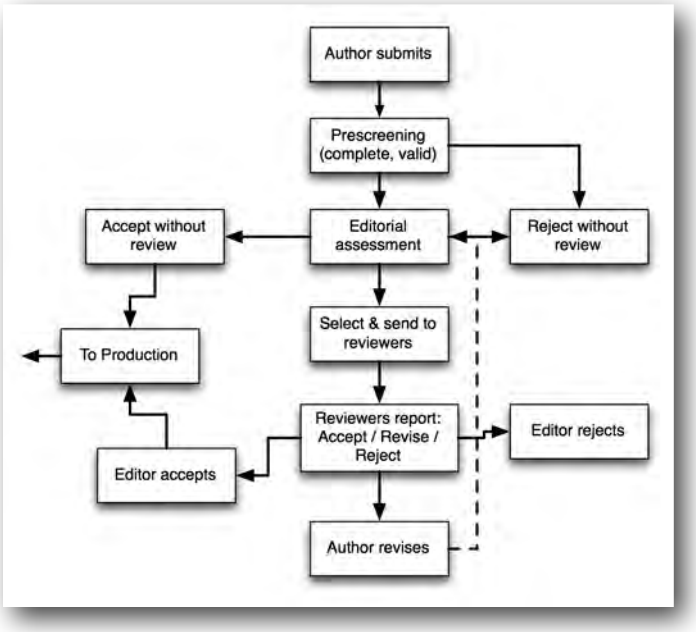


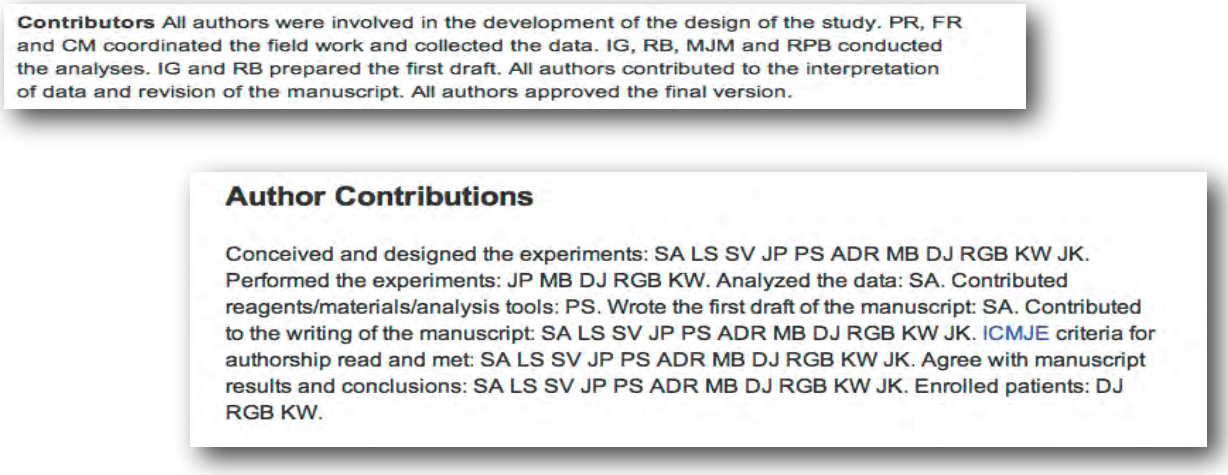
Figure 2: Typical peer review workflow (simplified)

Partly for reasons of general increased transparency, and partly in response to various misuses of the system, the definition of authorship has in recent years become more formalised and tightly defined. The key principles are that *all* those who contributed substantively to the research should be credited as authors, and that those who did not so contribute should *not* be given credit as an author. Past abuses have included "guest authorship" (e.g. attaching an eminent researcher's name to the paper to give it additional credibility, or perhaps to reward the researcher for some favour), and "ghost authorship" (concealing the true author, typically employed by a pharmaceutical company, and presenting the work as wholly by independent researchers). For medical and life science journals in particular, it is becoming normal for a statement describing the different contributions of each of the co-authors to be included at the end of papers (Figure 3 shows recent examples). Academic cultures do vary by discipline and country and some sensitivity needs to given to this; for example in some cultures it was the norm for the heads of department or laboratory to be listed automatically as a co-author, though this is now deprecated by most journals. The International Committee of Medical Journal Editors publishes criteria[1] for authorship and contributorship; some journals require authors to declare that they have read and met these criteria.

Editors & editorial boards

The role of the journal editor is critical to peer review. The editor is the person who takes the final decision on what is to be published in the journal, and what not, and takes ultimate responsibility for this decision. They are appointed by the journal's owner for their expertise and standing in a field, and play additional important roles for the journal (especially in determining the journal's overall policy and development path, and also in acting as a figurehead or ambassador for the journals, or soliciting articles), but this selection role is crucial. The reviewers's role, therefore, is *not* to take decisions on what is published, but to make *recommendations* to the editor who takes the final decision independently. (This is why the fact that reviewers do not reliably agree with each other is less important than it might otherwise be: they are not casting simple votes but making a case that the editor can weigh in the light of additional knowledge and experience.) Although editors are appointed by journal owners, their decisions are independent not just of the reviewers, but also of the owner or the publisher (if different from the owner).

[1] http://www.icmje.org/ethical_1author.html



Contributors All authors were involved in the development of the design of the study. PR, FR and CM coordinated the field work and collected the data. IG, RB, MJM and RPB conducted the analyses. IG and RB prepared the first draft. All authors contributed to the interpretation of data and revision of the manuscript. All authors approved the final version.

Author Contributions

Conceived and designed the experiments: SA LS SV JP PS ADR MB DJ RGB KW JK. Performed the experiments: JP MB DJ RGB KW. Analyzed the data: SA. Contributed reagents/materials/analysis tools: PS. Wrote the first draft of the manuscript: SA. Contributed to the writing of the manuscript: SA LS SV JP PS ADR MB DJ RGB KW JK. ICMJE criteria for authorship read and met: SA LS SV JP PS ADR MB DJ RGB KW JK. Agree with manuscript results and conclusions: SA LS SV JP PS ADR MB DJ RGB KW JK. Enrolled patients: DJ RGB KW.

Figure 3: Example contributor statements from (top) a recent article in *BMJ Open*, and (bottom) a more complex example in *PLOS Medicine*

In practice, of course, the role may be shared, for practical reasons (e.g. the journal may be too large for a single person to review all submissions) or to apply specialist knowledge to subfields where the scope of a journal is too broad for anyone to have sufficient expertise across its breadth. In this case, however, there is still a crucial role for the editor-in-chief to ensure that the delegated editorial process is fit for purpose and to oversee its operation to ensure it is working efficiently, effectively and fairly in practice.

It sometimes feels as if there are almost as many editorial structures as there are journals, and common terms such as "editorial board" have different meanings in different fields and at different journals, but the following are commonly used definitions:

- *editor-in-chief*: the main editor, as described above
- *editor*: a senior member of the editorial team, also has responsibility for policy-making and for taking decisions on papers, but reports to and is accountable to the editor-in-chief. At some journals, editors assess reviewers' recommendations and make provisional decisions subject to the editor-in-chief's final approval, while at others they take decisions independently (while remaining accountable to the editor-in-chief)
- *handling editor*, subject editor, regional editor, or specialist editor, etc.: categories of editor responsible for specified sub-sections of the journal
- *editorial board members*: depending on the journal, these may be editors as described above, or alternatively may play a limited role in the day-to-day peer review process but in effect act as advisory board members
- *advisory board members*: as the name suggests, these are usually responsible for advising on and supporting the journal's editorial policy, and may also act as senior reviewers
- *managing editor*: this will usually be a non-academic staff position (see below), but may sometimes refer to one of the editors with particular responsibility for overseeing the operation of the journal's editorial office and staff etc.

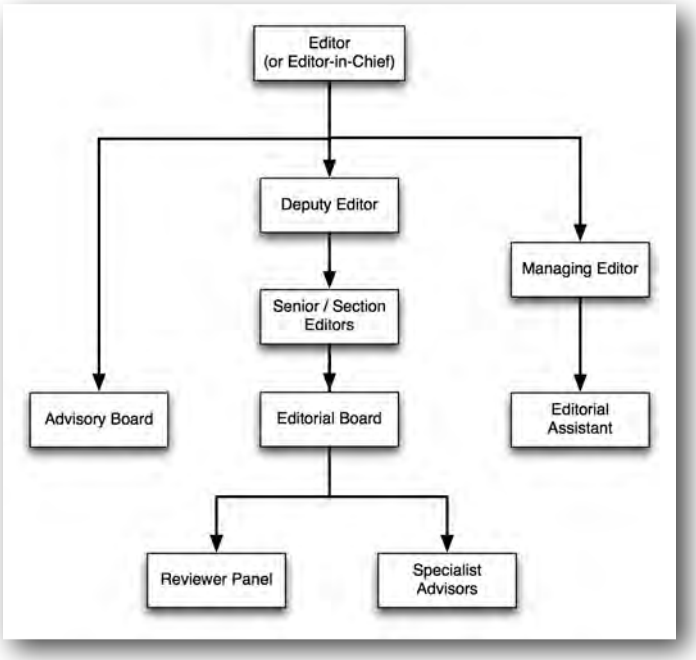


Figure 4: A typical editorial structure

Reviewers

Reviewers are experts in the field who are selected by the journal and receive manuscripts to review. They provide an assessment of the manuscript and report back to the editors on its suitability for publication and on any problems or particular considerations. Like authors, reviewers are expected to adhere to their own professional and ethical guidelines, including treating the manuscript in confidence, declaring any conflict of interest, and not taking unfair advantage of their privileged position. Reviewers are usually selected independently, but some journals may give consideration to the wishes of the authors (e.g. in suggesting reviewers to use, or those to avoid because of known conflicts) while retaining the final say.

Publishers and editorial staff

The *editorial office* refers to the management and administrative support team. The main roles are:

- *managing editor*: responsible for the editorial office and staff and for overseeing the day-to-day operation of the peer review and editorial processes. Liaises with and coordinates the activities of the other parties in the publication process. Oversees the implementation of journal policies and journal development plans under the direction of the editor-in-chief
- *editorial assistant*: assists and provides administrative support to the editors and managing editor, e.g. handles correspondence with authors, reviewers, editors, and other parties in the publication process, maintains records and updates statistical and other management reports as required.

The editorial office may be physically located at the publisher's premises, or at the editor's work location, or increasingly often be a virtual office with staff working from their own individual bases. For smaller journals the editorial office may be staffed by volunteers (for instance, the editors may undertake their own administrative work for the journal), but for larger journals the editorial office is more often provided by the publisher or by the society that owns the journal. In either case it is funded by the publisher, either directly from the journal account or indirectly (from funds remitted to the society under the publishing contract).

The publisher's role in peer review is therefore primarily managerial and supportive (the separation of editorial decisions from business policy being central to editorial independence) but nonetheless important. This is recognised by academics who do not only value peer review, but also value the role of publishers in it. For example, a 2012 survey by Ithaka S+R of UK academics found that of the various publisher roles, managing the peer review process to provide high-quality feedback was rated important by the largest share of respondents.

Publisher roles in peer review include:

- for journals it owns, the publisher will appoint the editor-in-chief and will hold them to account for maintaining the standards of peer review, adherence to appropriate codes of conduct, and ultimately the editorial quality of the journal
- appointing and managing the editorial office staff, and carrying these costs
- provision of, and support for, the online submission/tracking system and associated software and services.

Readers/commenters

Lastly, we should perhaps briefly touch on the role of the readers. They play no role in traditional pre-publication peer review, of course, but there is growing interest in various types of post-publication assessment and evaluation of articles. This is sometimes called post-publication peer review, although its function is clearly different to that of peer review as described here. These approaches are described below; briefly, the reader may create a "signal" about the quality or impact of a paper either passively as a byproduct of normal use (e.g. downloading the full text or storing its details in a reference management system), or actively through sharing, commenting on or rating.

3.3. Peer review workflows

We can now return to the peer review workflow in a little more detail (Figure 2):

- *submissions*: the corresponding author submits the manuscript using the journal's web-based system (see *Peer review submission and tracking systems* for more details on such systems)
- the submission system prompts the author to include some *metadata* about the paper (e.g. authors' full names and contact details and affiliations, title and abstract, subject keywords, source of grant funding, etc.) and perhaps some other information (e.g. suggested reviewers – or ones to avoid) and declarations (e.g. ethical consents, conflict of interests), before uploading the manuscript and any associated files
- *pre-screening*: submissions are checked for completeness and to ensure that they at least lie within the editorial scope of the journal in subject matter and type of article. Many journals also include automated or semi-automated technical checks at this stage, for instance testing for image quality or possible plagiarism
- *initial editorial review* ("triage"): with rising submission numbers, many journals include a stage of pre-review assessment of submissions by the editor-in-chief (or someone acting on their behalf) to select only the papers of suitable quality and relevance to proceed to full peer review. For some selective journals as many as 25–40% of submissions may be rejected at this stage
- *selection and invitation of reviewers*: depending on the journal, this may be done by the editor-in-chief, by another member of the editorial board, or in some cases by qualified editorial staff acting under the guidance of the editors. Most journals use two or three reviewers but some may use more. The journal will take account not just of the reviewer's

areas of expertise and interest, but also practical and other matters (e.g. current reviewing workload, track record of responding promptly, any known conflicts of interest)

- *reviewers submit reports*: most journals provide guidance and a structured template for reports. The guidance might include the general areas to be addressed by the report, such as: importance and relevance to the journal's audience, technical soundness, originality, degree to which conclusions are supported, clarity and style, length relative to substantive content, etc. Reviewers may also be asked to comment on specific matters like methods, data presentation, statistical design, and citations. The recommendations available to reviewers will again vary by journal, but may typically include: accept without modification; accept with minor modifications; accept subject to major revision; reject but encourage re-submission after revisions; reject
- *"first decision"*: the editor considers the reviewers' reports. If the reviewers do not agree, a further review may be sought or the editor may use their own judgement or seek additional advice from another member of the editorial board. In any case, the editor is not bound by reviewer recommendations but makes an independent decision. (Again, for some large journals, this decision may be delegated to editorial staff for clear-cut recommendations, with reference to the editors only for more complex decisions.)
- *the author revises* the manuscript in accordance with the editor's and reviewers' comments, and resubmits. Depending on the extent or complexity of the requested changes, the editor may assess the manuscript themselves, or may choose to return to the original reviewers for a view on whether their recommendations have been satisfactorily dealt with
- following *acceptance by the editor*, the manuscript is routed into the journal's production system. (If there is an open access publication charge it is only at this stage, on completion of the peer review, that any request for payment is made.)

3.4. Types of peer review

There are a number of variants of peer review. As mentioned at the beginning, this guide is exclusively concerned with editorial (journal) peer review. We shall also focus on the formal processes of pre-publication review, though we shall explore some newer developments in this area, and also look more briefly at informal approaches to post-publication review and assessment.

It is clear that pre-publication review is addressing a different need from post-publication assessment: pre-publication review traditionally includes an assessment of both the technical soundness and presentation, and also the originality and significance (and in the process improves publications along the way). Post-publication approaches could in principle also address both areas but the more systematic approaches focus on drawing attention to the more interesting and significant work (see *Post-publication review and article-level metrics*).

Single-blind, double-blind and open peer review

The main area of difference between approaches to peer review has been in the extent to which the authors' and reviewers' names are known to each other or hidden ("blinded").

The most common approach has been single-blind review, in which the authors' names are known to the reviewers, but the reviewers' names are withheld from the authors. The arguments in favour of this are that anonymity allows reviewers to write freely without constraint: reviewers (particularly junior and early-stage researchers) may find it difficult to criticise eminent researchers or those whose decisions may affect their own future careers if their criticisms are attributed. Conversely, knowledge of authors' identities can also help reviewers place papers in the context of earlier work.

Critics of single-blind review argue that the asymmetry allows biased or unfair reviewing, and more fundamentally that it is unfair for reviewers not to take responsibility for criticisms that could

negatively affect an author's career prospects (there are few if any consequences for reviewers for poor or incorrect reviews).

These criticism of single-blind review can be addressed in two opposite ways: by blinding both authors' and reviewers' identities, or alternatively by open review.

Double-blind review is the next most common approach after single-blind; here neither the authors' nor the reviewers' identities are disclosed to the other. The advantage is said to be a fairer system because reviewers' focus on the content of the work rather than *ad hominen* issues or biases linked to author identity, while still being able to criticise freely without fear of reprisal. Against this, it is argued that there is little empirical evidence that it is in fact better than single-blind or open review, and there are practical difficulties (internal clues make it hard to disguise authors' identities from knowledgeable reviewers) and editorial costs associated with the blinding process.

Open peer review is a somewhat baggy term, with the "openness" applying variously to the actors' identities, to the submitted manuscript and/or the reviewers' reports, and to the set of people able to comment on submitted manuscripts. As a minimum the authors' and reviewers' names will be known to each other, though journals then vary on whether the reviewers' names are subsequently made public by attaching them to the article (sometimes allowing reviewers to choose whether this is done). The arguments in favour of open review generally start from the lack of transparency and the opportunity for bias in single-blind review. Increasing reviewer accountability is said to improve the quality of reviews in terms of both tone and content, as reviewers take more care and avoid superficial work. Public linking of reviewers' names to articles would also give reviewers more recognition of their work.

Against open review is the fear that reviewers may have of reprisals, and at a practical level the degree of support for it may vary substantially by discipline, with some reviewers reluctant to undertake open review. Research by the *BMJ* prior to introduction of its open review system, and subsequent experience at the *BMJ* and Biomed Central, indicates that the majority of these reviewer populations are happy for signed reviews to go to authors but fewer to have their names disclosed publicly.

We shall discuss more approaches to open review below (see *Open and interactive review*).

3.5. Differences between subject disciplines

The arguments in favour of one approach to peer review over another are not cut-and-dried. The norms, standards and practices for peer review are largely set by individual scholarly communities, and are influenced by the nature both of the content and of academic discourse, as well as tradition in the field. In most cases publishers and journals seek to work within the grain of the communities they serve, though some do take leadership positions in advocating changes (particularly for more open review).

So for example double-blind review has traditionally been much more common in the humanities and social sciences than in the hard sciences. Double-blind review is growing in medical journals though less so in the related life sciences. Peer review in pure mathematics (where it is generally known as refereeing) is unusually robust and detailed (for instance referees will essentially verify new proofs), and consequently much more lengthy than in most fields. Many mathematicians, as well as physicists and economists, are also happy to share unpeer-reviewed manuscripts as preprints or working papers, whereas there is much more resistance to this practice in medicine where incorrect information could have damaging effects on patients.

3.6. Peer review submission and tracking systems

It is now extremely rare for journals in the STEM disciplines to operate without an online web-based submission and tracking system to manage the peer review process. Journals in the social sciences and (especially) the humanities have been slower to adopt such systems, perhaps because

journals in these fields are smaller on average and have placed less emphasis on speed of publication, but they are increasingly now the norm here too.

In technical terms, peer review systems consist of a content management system to store manuscripts, reviews and associated metadata, combined with role-based permissions management and workflow tools that route the tasks plus the associated content to the relevant users at the appropriate point in the peer review process, and reporting tools to provide statistics and management reports.

Users thus can have roles as authors, reviewers, editors or editorial administrators. (Individuals might well have multiple roles that would apply in different situations.)

Authors interact with the system by submitting their manuscript and associated metadata in the way already described. What happens next depends on the specifics of the journal's workflow (and hence systems have to be customisable to support the different workflows adopted by different journals), but typically the editor will be alerted (via email and/or via a new item on their "to do" list in the system), and so on as the article proceeds through the peer review process.

The systems store (editable) templates for all routine correspondence and can be set automatically to prompt reviewers when reports are overdue.

Examples of systems

Most publishers have chosen to use a system provided by a third-party vendor to avoid the need to develop and maintain their own systems.

The two leading platforms by market share are Editorial Manager (Aries Systems) and ScholarOne (Thomson Reuters); the effects of competition in the marketplace mean there is little between them in terms of features offered.

Other providers include eJournal Press, Bench>Press (HighWire), Rapid Review (Cadmus), AllenTrack (Allen Press), EdiKit (bepress), and EditFlow (MSP). The open-source Open Journal System publishing platform (Public Knowledge Project) also includes a peer review module which can be used as a stand-alone platform if desired, as does the new platform Scholastica.

Additional features

Systems also provide interfaces to other software and web-based services, allowing the core functionality to be extended. Some examples include:

- automatic parsing and linking of citations in the submission, making it easier for editors and reviewers to review the linked articles
- provision of access for editors to proprietary bibliographic databases, to help select reviewers and check references
- software algorithms to provide automatic identification of possible reviewers
- plagiarism checking of submissions: the CrossCheck system works by using the iThenticate software to compare submitted content against its database of published content. There is a limit to what is possible automatically: the software only identifies possible plagiarism candidates, which have to be evaluated by expert editorial staff to eliminate false positives
- automated production quality checks, for example testing that submitted images have sufficient resolution to reproduce adequately
- testing for image manipulation: this is currently a largely manual process to check that scientific images have not been inappropriately edited to "improve" the data

4. Peer review & misconduct

4.1. Ethical expectations in scholarly communication

While misconduct in research is relatively rare, it is by no means unknown. The numbers of article retractions, and their proportion of total articles published, have increased sharply over the last decade or so, though it cannot be determined from this whether incidence of misconduct is increasing, whether the misconduct is now more likely to be detected, whether ethical standards have risen, or some combination of the three. There are plausible reasons why all might be true (e.g. increased competition and pressure on researchers to publish; software and search engines; generally higher awareness and expectations of transparency on authorship and conflict of interest), but little empirical evidence on this. Most editors and publishers, however, nonetheless tend to view the rise in a favourable light, pointing to the increasing awareness of the issue and demonstration that the system can police itself.

Some surveys of researchers, however, have indicated that the prevalence of misconduct may be higher than previously anticipated. A 2005 account in *Nature* by Martinson, for instance, reported a third of scientists admitting to some form of relatively serious misbehaviour in the previous 3 years.

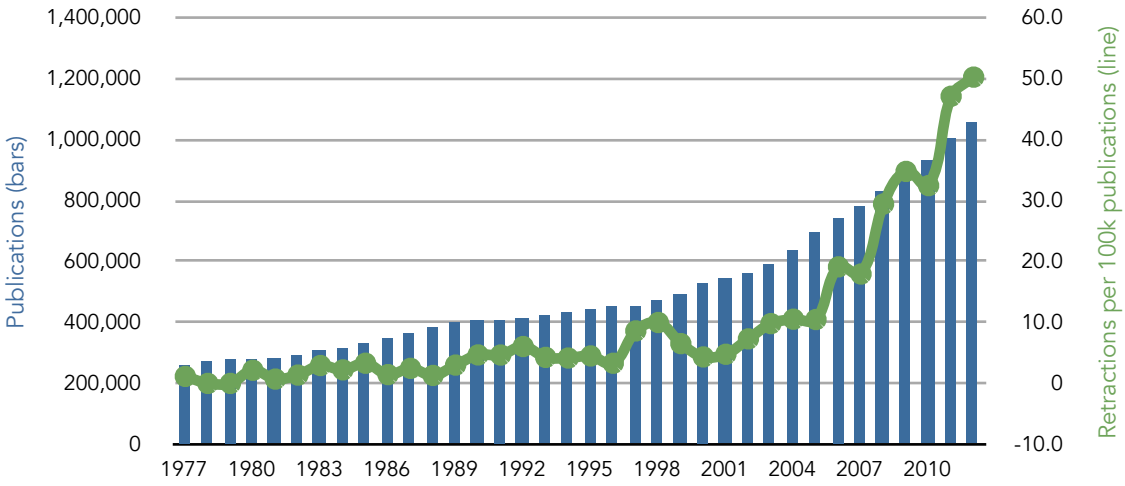


Figure 5: The number of article retractions has risen sharply over the last decade, in absolute terms and as a proportion of PubMed published articles (Source: http://pmretract.heroku.com/byyear)

Author misconduct

As authors carry out the original research and are primarily responsible for the content of their papers, they are the main focus of misconduct in publication, though there are opportunities for misconduct by reviewers and editors as well.

Authors' misconduct may relate to the conduct of the underlying research, or to matters that relate primarily to publication norms, although there is not a hard-and-fast distinction:

- *research misconduct* covers a spectrum of misbehaviour from fabrication and falsification of data at the most extreme, omitting or discarding data that does not support the authors' research, overlooking use of flawed data, or not maintaining adequate records
- *publishing misconduct* includes plagiarism, not citing others' work, not presenting work that contradicts their own, publishing the same data in multiple articles or multiple submission, giving inappropriate author credits, withholding details of methodology, and undeclared conflicts of interest

Reviewer misconduct

The scope for misconduct among reviewers relates primarily to abuses of their privileged position. The main areas are:

- failure to disclose competing or conflicting interests
- disclosure of confidential information without permission
- plagiarism of authors' ideas or results
- deliberate delay (e.g. to allow their own or another publication to be published first)
- making damaging personal attacks on the author rather than the work itself

Editor misconduct

Editors can also be responsible for misconduct. They have the opportunity for the same range of misbehaviours as those listed above for reviewers, and in addition editors may also misbehave in ways specific to the editor role, for instance they may:

- allow outside interests, commercial or otherwise, to affect editorial decisions
- allow decisions to be affected by inducements
- knowingly accept work that is fraudulent, wrong, or resulting from other misconduct
- use, or allow to be used, unethical means to increase the journal's Impact Factor
- circumvent proper peer review for the publication of their own work
- defamation of others

4.2. How journals handle misconduct

Where does peer review stand in respect of detecting and preventing misconduct, and what should be the role of the journal?

First, it should be acknowledged that peer review is not intended for, and is not an efficient or effective means for, the detection of deliberate research fraud, or indeed other forms of misconduct. Nonetheless, editors and reviewers may form suspicions of misconduct in the normal course of review, or by comparing information provided to that already known to them from other sources, or by having issues drawn to their attention by third parties.

In these circumstances the journal has a duty to investigate and take appropriate action when the facts are established. This is clearly a sensitive matter and a high level of care needs to be exercised, as individuals' reputations and careers may be at stake, and a botched or careless investigation could in itself open the journal to legal action.

The basic principles are those of natural justice: the facts are established to the fullest extent that is possible; allegations are put to the individuals involved and they are given a full and fair opportunity to rebut them; any sanctions applied at the outcome of the investigation need to be proportionate; and established due process must be followed at all stages. Any such investigation needs to be kept confidential, as premature disclosure of information may in itself be defamatory.

Journals therefore need to have documented policies and procedures in place to handle cases of possible misconduct. An excellent source of advice on good practice in this area is the Committee on Publication Ethics (COPE) – see below.

Given the complexity and risks involved, editors and journals should normally seek advice before embarking on investigations of the more serious allegations of misconduct or where there is any prospect of litigation.

4.3. COPE (Committee on Publication Ethics)

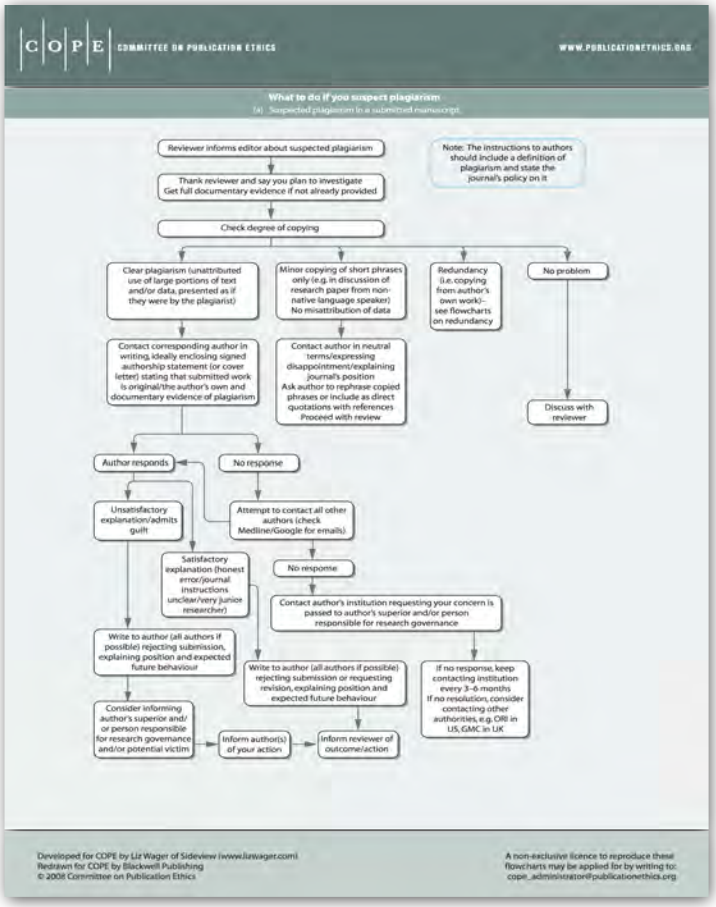


Figure 6: COPE flowchart for dealing with suspected plagiarism in a submitted manuscript (© 2008 Committee on Publication Ethics, reproduced with permission www.publicationethics.org)

The Committee on Publication Ethics (COPE) was founded relatively recently (in 1997) by a group of medical editors but has grown rapidly and now has over 7000 members including journals from all subject disciplines. COPE provides advice to editors and publishers on publication ethics, and specifically in relation to the handling of research and publication misconduct.

Much of its output is freely available to all (non-members as well as members), including:

- The COPE *Code of Conduct and Best Practice Guidelines for Journal Editors*
- Flowcharts on how to handle common ethical problems, including suspected plagiarism, duplicate publication, fabricated data, authorship issues, conflict of interest, ethical problems, and misappropriation of authors' ideas or data
- Other COPE guidelines (e.g. on retractions, guidelines for new editors, guidelines for new authors on the handling of authorship disputes, etc.)

An example of a COPE flowchart is reproduced in Figure 6, in this case illustrating the steps that need to be followed in cases of suspected plagiarism in a submitted manuscript.

In addition to these freely-available materials, COPE also provides advice and services as a benefit of membership, including: sample letters that can be adapted for journal use; advice on individual cases (via the Forum); access to an elearning package and an audit tool to compare member journals against COPE's guidelines; the ability to use the COPE logo in their journals; and some other benefits.

COPE membership comes with obligations as well as benefits. Members agree to adhere to the COPE Code of Conduct, and COPE will investigate complaints (for instance from an author) that the Code has not been followed. See http://publicationethics.org for more information.

5. Newer developments

5.1. Issues in scholarly communication: what can peer review offer?

While peer review enjoys very high levels of support among the academic community, it is not – as we have already noted – universally lauded. In recent years the level of scrutiny to which peer review has been subjected has reached historically high levels[2], and innovation and experimentation with new approaches to peer review has similarly expanded.

Before looking at some of these new approaches, it is worth considering what are the underlying issues in peer review, and in scholarly communication more broadly, that changes might attempt to mitigate. These include:

- longstanding issues of *fairness and bias* (as already discussed above)
- *delays*: peer review is said to slow down publication unnecessarily, delaying the point at which new results enter the literature and hence delaying the progress of science itself
- *inefficiency*: one major source of inefficiency that has come in for increasing criticism is that engendered by multiple sequential re-submission of rejected papers until a home is found, with the manuscript being reviewed again from scratch at each submission. The issue is compounded by pressures on authors to publish in the highest impact journals, and hence often aiming unrealistically high with the first submission before dropping down the pecking order. Nonetheless critics are surely right to argue that any gains in a relatively time-consuming (and hence expensive) process would be desirable
- *reproducibility*: there are concerns about the demonstrable lack of reproducibility in reported scientific findings, with absence of transparency in publication and the peer review process cited as one contributing factor
- *research data*: partly in response to the reproducibility question, but also to improve the efficiency of research more generally (and to improve the return on investments in research funding), there have been growing calls for research data to be shared more freely, and in particular for the research data underlying publications to be made available. The implications for peer review are unclear and are still being explored, but include coordinating and connecting the data and the article review, and connecting scientific review (i.e. assessing the scientific quality of the data), technical review (e.g., do formats and metadata meet accepted standards?), and data curation or annotation. For practical reasons it seems likely that most scientific review will take place post publication rather than following the pre-publication approach used for articles
- *information overload*: it is a truism that researchers (along with the rest of us) face an ever-increasing of torrent of information. Far more new papers are produced in total than any individual researcher could ever read, and even within relatively narrow specialties, reading all new papers would leave little time for anything else. Peer review as it currently stands already facilitates the filtering of papers into journals stratified by quality and selecting for topics relevant to a particular audience. Some argue, however, that this is an inefficient and ineffective means of filtering reading attention, does not reflect current means of article discovery, and fails to take advantage of new technologies. They argue that the filtering for originality and significance can be deferred until after publication.

[2] including for instance an investigation by the UK House of Commons Science & Technology Committee in 2011

5.2. Alternative approaches to pre-publication peer review

If these are the challenges, how might changes to peer review form part of the response? We can divide initiatives into new approaches to pre-publication review, and the more radical approaches that involve some kind of post-publication peer review.

"Soundness not significance" approaches

Probably the innovation in recent times that has had the largest impact on peer review (e.g. as measured by the number of articles affected) has been the "soundness not significance" approached pioneered by PLOS, Biomed Central, and some other open access publishers. The model is particularly associated with broad-scope non-selective (in terms of subject field) journals like *PLOS ONE*. Reviewers are asked to assess the *technical soundness* of submitted papers, but not to judge them by the more subjective criteria of *impact* or *significance*. The approach is frequently also associated with open access, with rapid reviewing approaches that discourage reviewers from requiring extensive revisions (e.g. involving a lot of additional new experiments), and with "cascade review" (see below), though none of these is central to the core innovation.

The rapid growth of *PLOS ONE* and widespread adoption of the "megajournal" model by other publishers suggests that the overall package is one that appeals to authors, or at the least, does not put off authors.

It could be argued that the "soundness not significance" approach is really only half of the story. It has radically changed the pre-publication stage of review, but was originally designed to be complemented by new post-publication techniques that would identify and "filter forward" significant and important work. The original ideas for this (comments and ratings attached to individual articles) have failed to gain support, and the perhaps more promising techniques based on usage data and social media signals (see *altmetrics*) have yet to deliver widespread useful results. As a consequence large megajournals may publish many thousands of articles a year across a broad range of subject disciplines with no effective means for authors to focus their finite attention.

Cascade review

Cascade peer review addresses the inefficiency involved in manuscripts facing multiple re-reviewing when they are resubmitted to a new journal after being rejected by a previous journal. The basic idea is that the original reviewers' reports should be transferred to the new journal where review can then build on what has already been done rather than starting afresh.

This approach is easier to implement within a publisher's own portfolio of journals. It is often associated with open access megajournals using "soundness not significance" review policies, particularly with the idea that higher impact, highly selective journals can feed submissions that are technically sound but fail to meet their criteria for significance or relevance to their particular audience. This proposition may well be attractive to an author: rather than take one's chances with a new submission elsewhere, a paper rejected on this basis will have a good chance of rapid acceptance in the associated megajournal.

Cascade reviewing could also be implemented between journals with different publishers, though this is relatively uncommon. The Neuroscience Peer Review Consortium, formed in 2008, is the best-known example, in which some 40 journals from multiple publishers agree to share reviewer reports (with the author's consent). Uptake by authors is, however, reported to be very low at only 1–2% of papers. The journals *BMC Biology* and *eLife* (owned by the research funders Wellcome Trust, Max Planck Society and Howard Hughes Medical Institute) have also recently announced that their rejected authors will have the option of taking the reviewers' reports with them.

Portable peer review

A more radical approach would be to separate peer review from individual journals entirely, with the review being carried out separately and reviewer reports being attached to manuscripts for the benefit of any journals that the author chose to make them available to. This idea of "portable review" is currently being pioneered by two new start-ups, Rubriq and Peerage of Science. The core concept is the same at both, with reviews provided by an independent panel of reviewers, but their business models are different. Rubriq seeks to charge authors a fee (shared with reviewers) for a service that includes fast peer review (1–2 weeks) and recommendations for suitable journals, while Peerage of Science charges publishers a fee for each paper published (publishers would in effect be outsourcing their peer review costs under this model). These models fit most easily with non-selective megajournals, which by definition conduct little journal-specific review already, but it is far too early to judge whether portable review will gain a significant following.

Open and interactive review

As noted above, the "open" in open peer review can refer to a number of aspects, including the authors' and reviewers' identities, as well as the reviewers' reports and associated editorial correspondence, and the set of people able to comment on submitted manuscripts prior to publication. We have already discussed the question of blinding or otherwise of author/reviewer identities, and will now turn to the other dimensions of openness.

Publication of reviewer reports and associated editorial correspondence is becoming an increasingly normal feature, although only a small minority of journals have yet adopted it.

A more radical approach to open peer review has been pioneered for some years by the journal *Atmospheric Chemistry & Physics* and is being extended to the other journals owned by the European Geophysical Union. Two stages of review are employed. In the first stage, submitted manuscripts are first screened for general suitability and the manuscript is published by the journal as a "discussion paper". Discussion remains open for 8 weeks, during which time the (editor-commissioned) reviewers' reports, author responses and community/public comments are all made public. Reviewer reports and comments can be anonymous or signed; about three-quarters of reviewers choose not to disclose their names. In the second stage, manuscript revisions and follow-up review proceeds privately as in traditional review. If accepted the paper is published in the main journal. If not accepted, the discussion paper and associated comments are permanently archived and available online. A somewhat similar approach is used by the journal *F1000 Research*, which publishes articles immediately (subject to internal screening) and then commissions reports from two or more reviewers. The peer review status is shown in the article's metadata, and only papers that pass peer review are listed in bibliographic databases.

A few journals use more interactive or consensual approaches, working from the basis that the intention is to make the paper as good as it can be (once it has reached some threshold), rather than setting hurdles for rejection. In this approach, online forums are used for discussion between the editor and reviewers, or in some cases for discussion between the editor, reviewers and authors. These discussions are open in the sense the identities of all actors are known to each other, but otherwise private. Such approaches add value to the peer review process for authors and in due course readers, by improving papers and reducing the adversarial elements of reviewing, but come at a cost in terms of reviewers' time and may not therefore be easily scalable to all journals.

Registered reports

In this model, currently being pioneered by the journal *Cortex,* the peer review is split into two stages. First, experimental methods and proposed analyses are pre-registered and reviewed before data are collected. If peer review is favourable at this stage, the paper is accepted "in principle". This guarantees publication of the authors' future results providing that they adhere precisely to

their registered protocol. Once their experiment is complete, authors then resubmit their full manuscript for final consideration. The intention is to reduce *publication bias*, that is, the tendency to prefer positive to negative findings or null results, even though the negative findings may in fact result from studies with greater statistical power or technical rigour.

5.3. Post-publication review and article-level metrics

The other new approach to peer review is to conduct assessment of research articles after publication rather than before.

In its most radical form, a system of post-publication review would see papers published without any prior review (except possibly some minimal screening, as for instance at the arXiv preprint server), with various kinds of appraisal, rating and review, both formal and informal, taking place subsequently. The core argument is that filtering prior to publication is ineffective, and is costly and time-consuming: rather than filter then publish (which was necessary when resources for publication – print and paper – were finite), we should publish (using the essentially infinite space of the web) and then filter, making use of newly available technologies.

A more pragmatic approach to post-publication review sees it complementing conventional review, rather than replacing it. In this approach it might also be combined with simplifications to pre-publication review, in particular the "soundness not significance" approach, based on the argument that significance is more effectively determined after publication.

Comments and ratings

Post-publication review can be thought of as the systems (actual and proposed) to review or critique and filter journal articles using article-level comments and ratings (which may be sourced from the journal website or elsewhere on the web), and other article-level metrics including different kinds of usage, and formal and informal citation data.

Early approaches emphasised comments and ratings (or "likes") attached to individual articles on the journal's website, consciously modelled on the systems used by online retailers. Such systems have so far failed to gain support from the research community and are relatively little used, and research shows that authors rarely bother to reply to online criticisms of their work posted outside the framework of peer-reviewed literature. The data gathered is also of low quality (e.g. insubstantial comments, indiscriminate ratings), at least when taken in isolation.

altmetrics

A more fruitful approach may be to combine multiple "signals" into a broader measure of impact, an approach sometimes called "altmetrics". These signals can include journal-hosted comments and ratings where they exist, but in combination with external signals, particularly those from social media. These external signals include mentions in blog posts or tweets, mentions on news stories, bookmarking in social bookmarking tools, and so on. These data can be combined with article-level usage data of various kinds, including downloads, views, ILL/document delivery, bookmarking, annotating, sharing and forwarding, downloads of associated datasets, etc., and with citation data (including from a broader range of sources than used in standard citation metrics like the Impact Factor, such as patents and grey literature).

Services currently available include those from Altmetrics, ImpactStory and Plum Analytics. As these services become more complex and integrate a wider range of data (especially citation data), they start to overlap with the more conventional citation-based research assessment services provided by Thomson Reuters (Journal Citation Reports, Impact Factor, and InCites) and Elsevier (Scopus, SciVal), which till now have operated at the aggregated level of journals or research organisations. The search engines Google Scholar and Microsoft Academic Search have also both launched article- and researcher-level metrics.

Article evaluation and tiering systems

Another approach is to use more sophisticated algorithms based on article usage patterns to rank or tier papers by impact (e.g. the *Frontiers* journals).

Overlay journals and review

More formal approaches to post-publication include the overlay journal. For instance, an editorial board (perhaps sponsored by a learned society or other interested party) might review and select papers from online repositories or preprint archives, which they would collect together into a virtual journal, perhaps with associated editorial commentary. Although the idea has been discussed for many years, there are as yet no notable examples.

A similar approach is used by the *Faculty of 1000* service: its editorial panel (originally comprising 1000 researchers, though now much larger) selects noteworthy papers from the published (and already peer-reviewed) literature, and adds an editorial commentary on each. Clearly this adds to, rather than replacing, pre-publication peer review.

6. Further reading

Books

The following books were useful sources in preparing parts of this guide and are recommended for those looking for more detail.

Editorial Peer Review: Its Strengths & Weaknesses, by Ann Weller (ASIST 2002). This is now out of print (but copies are easily available online) and a little dated in some areas, but provides an excellent overview

Peer Review and Manuscript Management in Scientific Journals, by Irene Hames (Wiley-Blackwell 2007). A more recent book offering a highly practical treatment, with lots of examples of sample checklists, forms, guidance and editorial correspondence

How to Survive Peer Review, by Liz Wager (Wiley-Blackwell 2002). An alternative perspective, written for academics facing peer review

Reports and articles

The following reports and articles provide additional depth and more recent coverage of some the topics covered in this guide.

Peer review in scholarly journals: Perspective of the scholarly community—an international study (Publishing Research Consortium 2008). Report of a large international survey of academics http://www.publishingresearch.net/PeerReview.htm

Peer review: Benefits, perceptions and alternatives (Publishing Research Consortium 2008). A summary digest of the previous report http://www.publishingresearch.net/documents/PRCsummary4Warefinal.pdf

"I don't know what to believe" (Sense About Science 2013). A guide to peer review aimed primarily at a lay audience http://www.senseaboutscience.org/data/files/resources/16/IDontKnowWhatToBelievereprint2008.pdf

Peer review survey 2009 (Sense About Science 2009). Another large-scale international survey http://www.senseaboutscience.org/pages/peer-review-survey-2009.html

Peer Review: recent experience and future directions, *New Review of Information Networking* 16:1, 23–53 (2011) doi:10.1080/13614576.2011.566812

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Martinson, Anderson, & de Vries. (2005). Scientists behaving badly. *Nature*, 435. doi: 10.1038/435737

Ware, M., & Mabe, M. (2012). *The STM report: An overview of scientific and scholarly journal publishing. Third edition*. International Association of Scientific, Technical and Medical Publishers. doi:10.1300/J123v40n01_12

7. Sources of advice and information

General advice

General advice on scholarly publishing including peer review:

- ALPSP (Association of Learned and Professional Society Publishers) http://www.alpsp.org.uk
- STM (International Association of Scientific, Technical & Medical Publishers) http://www.stm-assoc.org
- SSP (Society for Scholarly Publishing) http://www.sspnet.org

Editing and codes of conduct

Peer review, editing, codes of conduct and handling misconduct:

- COPE (Committee on Publication Ethics) http://publicationethics.org
- WAME (World Association of Medical Editors) http://www.wame.org
- ICMJE (International Committee of Medical Journal Editors) http://www.icmje.org

Research integrity

Oversight of research ethics and integrity:

- UK Research Integrity Office http://www.ukrio.org
- Office of Research Integrity (US) http://ori.dhhs.gov

Research funders

All major research funders publish guidance on research integrity or similar. Some examples:

- Howard Hughes Medical Institute http://www.hhmi.org/about/research/policies.html
- Max Planck Society http://www.mpg.de/229644/Research_freedom
- National Institutes of Health http://grants.nih.gov/grants/research_integrity/
- Research Councils UK http://www.rcuk.ac.uk/research/Pages/ResearchIntegrity.aspx
- Wellcome Trust http://www.wellcome.ac.uk/About-us/Policy/Policy-and-position-statements/WTD002753.htm

Introductory guide for reviewers 3. publishingsupport.iopscience.org. An introduction to the peer-review process. What is peer review? Peer review is the process used to assess an academic paper before deciding whether it should be published or not. The paper is looked at by experts in the field, known as reviewers or referees. One or more reviewers will comment on the quality, originality and importance of the work. This information can then be used by the Editors of the journal to make a publication decision, and by the authors to improve their paper. Why peer review? The peer-review system Guide to Peer-Assessment. Dr. Michael Wride. Academic Practice, University of Dublin Trinity College 2017. Co-funded by the Tempus Programme of the European Union. Academic practice and elearning (capsl) resources assessment: guide to peer-assessment.Â This pamphlet aims to introduce formative and summative peer assessment to academics who are considering implementing peer review in their teaching. It provides a â€˜theory into practiceâ€™ approach and outlines techniques and examples for using formalised peer assessment more directly in the design of curricula and in making its use more explicit in the classroom in order to help students learn more eectively. Introduction: Why use peer assessment? Peer review helps the publisher decide whether the submitted work should be accepted, considered acceptable with revisions, or is rejected. For a flowchart description of the peer review process at IntechOpen please see below. IntechOpen is dedicated to publishing high-quality content and we are a member of the Committee on Publication Ethics (COPE), all referees and Editors are instructed to review submissions in line with the COPE Ethical Guidelines for Peer reviewers.Â Peer-Review: An Introduction and Guide, PRC. Alan Meier's Guidelines for Peer-Review of Technical Papers. Publons Peer Reviewer Academy.