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Motivating and Maintaining Ethics, Equity, Effectiveness, Efficiency, and Expertise in Peer Review*

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Abstract

Scientists who engage in science and the scientific endeavor should seek truth with conviction of morals and commitment to ethics. While the number of publications continues to increase, the number of retractions has increased at a faster rate. Journals publish fraudulent research papers despite claims of peer review and adherence to publishing ethics. Nevertheless, appropriate ethical peer review will remain a gatekeeper when selecting research manuscripts in scholarly publishing and approving research applications for grant funding. However, this peer review must become more open, fair, transparent, equitable, and just with new recommendations and guidelines for reproducible and accountable reviews that support and promote fair citation and citational justice. We should engineer this new peer-review process with modern informatics technology and information science to provide and defend better safeguards for truth and integrity, to clarify and maintain the provenance of information and ideas, and to rebuild and restore trust in scholarly research institutions. Indeed, this new approach will be necessary in the current post-truth era to counter the ease and speed with which mis-information, dis-information, anti-information, caco-information, and mal-information spread through the internet, web, news, and social media. The most important question for application of new peer-review methods to these information wars should be 'Who does what when?' in support of reproducible and accountable reviews. *Who* refers to the authors, reviewers, editors, and publishers as participants in the review process. *What* refers to disclosure of the participants' identities, the material content of author manuscripts and reviewer commentaries, and other communications between authors and reviewers. *When* refers to tracking the sequential points in time for which disclosure of whose identity, which content, and which communication at which step of the peer-review process for which audience of readers and reviewers. We believe that quality peer review, and peer review of peer review, must be motivated and maintained by elevating their status and prestige to an art and a science. Both peer review itself and peer review analyses of peer reviews should be incentivised by publishing peer reviews as citable references separately from the research report reviewed while crossreferenced and crosslinked to the report reviewed.

Keywords

Open peer review, reproducibility, accountability, research integrity, citational justice, endorsements, retractions, peer review of peer review.

Contents

Introduction

With the growth of online web technologies in recent decades, the number of published research papers has increased by 5% per annum (R. Walker and Rocha da Silva, 2015). Thousands of scientists publish an article every five days (Ioannidis et al., 2018). Numerous publish-

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ers offer incentives to spur publication of more papers in their journals, many of which can be considered for-profit and/or predatory, where the objective appears to be quantity rather than quality (Elmore and Weston, 2020). Publishers in some countries, such as China, South Korea, and Pakistan, even offer cash rewards for publishing papers (Fuyuno and Cyranoski, 2006). While the number of publications increases (R. Walker and Rocha da Silva, 2015), the number of retractions increases at a faster rate (Cokol et al., 2008), (Redman et al., 2008), (Grieneisen and Zhang, 2012), (Steen et al., 2013). These retractions reflect the failures of the peer review process at journals to identify deficiencies in documents prior to publication.

In the latter half of the 20th century, as the number of researchers writing scholarly articles grew rapidly, peer review took on its current role of selecting which papers were worthy of publication and, in effect, of other scholars' attention (Spier, 2002). Indeed, across the spectrum of scientific fields, most researchers believe that a scientist's career hinges upon peer review, that it determines professional recognition, research funding, approval of projects, career advancement, and job security in industry or tenure in academia (Hojat et al., 2003). Thus, the demand for high-quality, transparent and fair peer reviews remains high due to the role of publications and citation metrics in institutions' decisions concerning which research projects to fund and which scientists to hire. However, traditional peer review has not been up to the challenge and continues to suffer as a "system under stress" (Gropp et al., 2017).

At journals claiming to use *peer review* during the *pre-publication* phase to scrutinize and evaluate the quality of content submitted prior to publishing it, the journal editors invite research experts in the same field to review, comment, and critique the manuscript before making the final decision to *accept or reject* it for publication. Historically, this approach to reviewing and publishing content involved a lot of clerical and administrative work with much of the screening and selecting of manuscripts done to prevent wasteful use of physical ink and paper on reports deemed of insufficient quality. However, since the 1990s with the emergence of the internet, web, computers, and electronic digital publishing, peer review has been experiencing a revolution (Laakso, Welling, et al., 2011). Publishers can now choose from a wide variety of computerized manuscript management systems, both commercial and non-commercial (Kim et al., 2018).

Digital publishing eliminates or automates much of the clerical and administrative work, thereby enabling easier access and participation for all parties in the processes of reviewing, publishing, and when necessary retracting, scientific reports. Web technologies also support the peer review process by making it more timely and potentially more open, transparent and collaborative rather than closed and opaque. This transformation of traditional peer review has become known as open peer review (OPR) (Ford, 2013) in the open science movement (Wolfram et al., 2020) with improving support from various initiatives such as (OASPA, 2008), (Schiltz, 2018), (Craig and C. Taswell, 2018), (Craig, Ambati, Dutta, Kowshik, et al., 2019), (S. K. Taswell, Triggle, et al., 2020), (Hosseini et al., 2020), (Limbu, 2020), (T. G. Gerwing, A. M. A. Gerwing, Choi, et al., 2021) and (Waltman and Polka, 2022).

The title of our report, "Motivating and Maintaining Ethics, Equity, Effectiveness, Efficiency, and Expertise in Peer Review", provides a slogan with the important qualities that we believe define good peer review in this new era of online digital publishing. From incentivizing active participation and engagement of reviewers by making their quality reviews citable references to supporting this open review process with computer software and artificial intelligence, the quintuple 'E's of "Ethics, Equity, Effectiveness, Efficiency, and Expertise" call attention to the importance of developing and promoting solutions for maintaining excellence in each one of the '5E's.

We report on progress in the study and analysis of peer review and the factors that affect it in order to reveal actionable insights to improve peer review methods for all stakeholders, both within and outside the scientific community. This report delves into the peer review process for digital publication and retraction, discusses open access (OA) journals, summarizes different peer review models, examines a variety of current manuscript management systems, and then relates the discussion to artificial intelligence as support technology for the evaluation of manuscripts and the *peer review of peer review*.

Scientific Research Costs

Every year throughout the world, diverse organizations spend billions of dollars on research projects in many different scientific fields, from astronomy to zoology, from climate change to public health, with America alone spending one third of the world's research budget in 2019 (Sargent, 2021). Many of these studies depend on financial support from government agencies in the form of grants of hundreds of thousands to many millions of dollars, leading to concern among tax-paying citizens about whether this government-funded research can benefit society enough to justify the cost (Sanz-Menéndez et al., 2014). As a recent important example, consider the large-scale mobilization of the biomedical research community to fight the COVID-19 pandemic, spurring many studies on vaccines, variants, testing, treatment, and prevention (Centers for Disease Control and Prevention, 2022). By the time infection rates reached their peak in March of 2020, the U.S. Federal Government had issued around $4.9 billion in emergency grants (US Department of Treasury Data Lab, 2022), (National Institutes of Health, 2022).

Even though the public paid for this research, much of the information published remained behind paywalls or was subjected to a delayed or rushed peer review process without adequate transparent peer review, which later resulted in many retractions of these papers proven to lack trustworthiness. Deficiencies in accessibility and transparency can lead to a decline of trust in government-funded science in general (Kreps and Kriner, 2020). Countering the spread of pseudo-science driven by partisan political agendas requires a new model for open science that includes both open peer review and open access to both data and results, allowing the public to view the discussion of evidence, argument, and counterargument as it progresses through the sequential steps of the scientific method. This approach to the acquisition of knowledge for the common good and public health could lead to more public awareness about current research, and thus, to more involvement and engagement with that research (Wynne, 2006). Evidence of the good intentions and attainable goals of scientific endeavors could then counter the rhetoric decrying 'wasteful research' (Vuong, 2018)(Kreps and Kriner, 2020).

While the overall level of trust in science had remained stable from the 1970s to the 2000s, more recently growing mistrust among conspiracy theorists has turned facts into political footballs (Gauchat, 2012). Claims that COVID-19 is fake and that vaccines and masks are ineffective, combined with the disinformation spread by the Trump administration, lead to "unnecessary wave[s] of COVID-19 cases and deaths" (Hotez, 2022). Researchers have been obligated to devote time and effort to debunking baseless claims of vaccines containing fetal cells, causing infertility, or harming pregnant women (Mayo Clinic Health Sys-

tem, 2021). These false claims and other myths about COVID-19 have contributed (Jennings et al., 2021) to low rates of vaccine acceptance in the US (56.9%), Russia (54.9%), and elsewhere (Sallam, 2021). This distrust of science intertwined with the cost of research can lead to strong disbelief in the positive value and real benefits of true science and scientific research.

Maintaining consistent standards for quality peer review, especially when completed as uncompensated and unrecognized work that some analysts have estimated to constitute "a billion-dollar donation" (Aczel et al., 2021), could help to combat pseudo-science and to increase public trust in authentic science. More research published through open access could garner more public trust in science. According to one study, participants rated 'unsuccessful' research, that is, research from projects that failed to demonstrate tangible benefits, as more expensive than 'successful' research, even when the two programs had the same monetary cost (Vuong, 2018). When the citizens paying for research become more confident in the value and benefits of science, they are more likely to advocate further research. This outcome can then lead to a virtuous cycle in which directing more funding toward research guided by high ethical standards with high-quality peer review leads to greater public benefit and further strengthens society's trust in science (Vuong, 2018).

Open Science, Data Access, and Peer Review

Traditionally, scientific journals published in a physical format (such as bound issues printed with ink on paper) have required a fee-based subscription (Fyfe et al., 2017). Over the past several decades, many scientific journal publishers have converted to electronic digital distribution online via the internet (Fillmore, 2015). With this change in how journals disseminate scholarly research communications has come a rethinking of who should pay for publication (Tennant, Waldner, et al., 2016), with an increasing number of research reports becoming OA, about 28% as of 2018 (Piwowar et al., 2018). At the same time, accelerating research output has created more demand for timely and transparent peer review (Gropp et al., 2017). The COVID-19 pandemic, with the effort to develop vaccines rapidly, led to growth in support for open science and open access due to the desire to encourage innovation in the development of and trials for new vaccines (Vuong et al., 2022).

Research publishers have adopted a variety of different models for 'open access' publications, most of which have been given names corresponding to colors or metals (see Table 1). The distinctions among these models generally hinge on who pays for what and who has what rights to redistribute or otherwise reuse the published work. In particular, the most commonly mentioned distinction has been between "gold OA" wherein journals themselves host publicly available versions of articles, and "green OA" (also known as self-archiving) wherein the author has permission to make a separate version available in an open repository (Harnad, 2004). Since readers no longer need to pay in order to access the article, but the publisher still needs to fund its operations, journals using the gold model typically require that authors pay an article processing charge (APC) to request publication of their articles (Harnad, 2004). As a consequence, the self-archiving OA model has grown in popularity much faster than the journal-hosted OA model, with 90% of journals permitting it by 2004 while fewer than 5% had removed the paywalls from their own sites (Harnad, 2004).

The growth of OA journals has occurred due to both the establishment of new journals and the conversion of established journals to OA models, but converting a journal to full OA can pose both risks and/or benefits for a for-profit publisher (Björk and Korkeamaki, 2020). Consequently, a growing number of journals, including many from Springer Nature, Elsevier, Taylor & Francis, and some of the largest publishers of scholarly research communications, have not fully embraced OA but instead adopted a hybrid OA model wherein authors can choose between having the journal keep their work behind a paywall or paying article processing charges (APCs) to make the publication freely accessible to readers (Laakso and Björk, 2016). Other journals have developed a different strategy for mixing closed and open access: requiring users to pay for access to any newly-published article, then making it freely available after some fixed amount of time has passed, usually one year (Laakso and Björk, 2013).

At the other end of the spectrum, some new journals have even abandoned the usual model of soliciting new articles entirely and instead curate collections of preprints gathered from OA repositories such as ArXiv (Brown, 2010). These curated archives, called overlay journals (or epijournal in French), take on the tasks of peer review and selection for quality and relevance to a particular field, thus assuming the traditional editorial responsibilities of journals while leaving the task of distributing copies of the reports to the OA repository (Brown, 2010). These overlay journals often use an open copyright such as the Creative Commons Attribution 4.0 license (CC, 2013).

Despite the proliferation of different OA models, the perceived lower prestige and concern over the cost of publishing in an OA journal make many researchers hesitant (Schroter and Tite, 2006). One 2016 study found that APC fees at full OA for authors in the US, Western Europe, and Canada averaged around 2000 USD while fees at hybrid journals were higher at a mean of nearly 3000 USD (Solomon and Bjork, 2016). Whereas only 30% of OA journals charge APCs, the ones that do publish 50% of all peer-reviewed OA articles (Tennant, Waldner, et al., 2016).

Both publishers and research institutions are taking steps to alleviate these costs. Of the journals that do charge APCs, 69% offer fee waivers to authors from low-income countries (Tennant, Waldner, et al., 2016). Furthermore, some institutions pay the APCs on behalf of their members, either on a per-article basis or as a single lump-sum subscription fee (Burchardt, 2014). This approach has been favored by one of the largest efforts to support open-access, the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP3), the 3000 member institutes of which have agreed to redirect the funds of their libraries away from paying for journal subscriptions and toward paying the APCs needed to publish their investigators' scientific work in OA journals (Kohls and Mele, 2018).

However, this approach excludes many researchers working outside of academic institutions from publishing in some of the most influential and expensive journals, for example, approximately 30% of authors who published in Danish periodicals in 2010 (Burchardt, 2014). Such findings show that models for publishing scholarly research communications need to evolve further before all published work can compete for impact on an equal playing field with success depending solely on their merit and the quality of their content. The diversity of approaches to OA models suggests there remains ample opportunity for creativity in finding new ways to pay the costs of a peer-reviewed OA journal. A current list of business models and revenue sources for OA journals includes: advertising, auction, crowdfunding, e-commerce, endowments, fund-raising, hybrid OA journals, institutional subsidies, priced editions, publication fees, submission fees, temporary OA, third-party licensing, value-added services, and contributions from volunteers and donors.

Another business model has been to publish in a hybrid journal with-

Table 1: Color names for open access models.

Name	Description	Reference
Black	publications that have bypassed paywalls and have been illegally released to be made freely accessible by the public	"Gold, green, and black open access" by Bo-Christer Björk and "Green, Gold, Diamond, Black — what does it all mean?" by Lucy Barnes
Blue	The author(s) can archive post-print, or the digital draft after it has been peer-reviewed, but cannot do so with the pre-print	"The Many Colors of Open Access" by Scott Ahlberg and "A Guide to Understanding the Colors of Open Access" by IGI Global Open Access Division
Bronze	freely avaliable journal article that has no open license	"The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles" by Robert McDonald
Gold	The final version of manuscript is freely available immediately upon publication by the publisher. Article processing fees are usually charged towards the author or an institution	"Types of Open Access" by Open Access Academy and "Gold open access and green open access: what's the difference?" by Jasmin Schmitz
Green	An earlier version, before publication, it is posted in repositories and online where it is made permanently and freely avaliable online for anyone. Also known as self-archiving.	"The Open Access Interviews: Héléne Bosc" by Richard Poynder and "What are the gold and green open access publishing options?" from Taylor & Francis author services
Hybrid	Some of the articles are open access, typically with a publication fee	"Make your article open access in hybrid journals" from Wiley & Sons author resources and "Open Choice: Your research. Your choice." from Springer-Nature author resources
Platinum (aka Diamond)	scientific articles published without charging authors or readers for article processing charges	"What is diamond / platinum open access?" from the OAPEN FAQ, and "Diamond Open Access, Societies and Mission" by Robert Harrington
White	The author(s) do not have the right to archive, pre-, post-print, or any other versions.	"The Many Colors of Open Access" by Scott Ahlberg
Yellow	The author(s) can archive pre-print, or the version before general publication, but cannot do so with the post-print	"Open Access: Many Colors of Open Access" from the DePaul University Library and "The Many Colors of Open Access" by Scott Ahlberg

out paying APC fees while distributing the manuscript in open archives on a repository. The article's final version will be available only to subscribers on the journal's website, while a near-final and peer-reviewed version will be available to all on the open archive (Pourret et al., 2020). Some OA publishers are non-profit organizations, such as the Public Library of Science (PLoS), while others are for-profit businesses, such as BioMed Central (BMC). SCOAP^3 is a global partnership of 3,000 libraries, funding agencies, and research institutions from 44 countries and 3 intergovernmental organizations. Working with leading publishers, SCOAP^3 has converted key journals in the field of High-Energy Physics to OA at no cost for authors. SCOAP^3 centrally pays publishers for expenses involved in providing OA. Publishers, in turn, reduce subscription fees.

The International Congress on Peer Review held in Prague in 1997 was one of the first conferences to bring together experts who presented both work exposing the biases and inadequacies of conventional peer review and a new approach that promised to correct them: open peer review (Smith, 1997). In the most ambitious visions, a scholarly work would no longer be frozen upon publication but would remain a living document where readers could see the reviews and revisions that preceded acceptance, submit their own, and follow the debate as new evidence arose (Smith, 1997). In the years since then, different models of open review have ranged from making every stage of the process a matter of public record to merely disclosing the names of the reviewers to the authors (Ford, 2013; Ross-Hellauer, 2017). Whatever the details of the procedure, guided by the desire to improve the quality and efficiency of peer review, the goal has been to make peer review more ethical and transparent by putting authors, reviewers, and editors on equal footing and holding all accountable for their words and actions (Smith, 1997). The call for open peer review has also become part of the broader open science movement, which (Vicente-Saez and Martinez-Fuentes, 2018) define as "transparent and accessible knowledge that is shared and developed through collaborative networks," which encompasses the open availability of not only data but also software tools and discussions of experimental design and analysis (Vicente-Saez and Martinez-Fuentes, 2018). A prominent example of putting the princi-

ples of open peer review into practice is OpenReview, a free platform for managing conference and journal submissions where all manuscripts, reviews, and editorial comments are not only publicly available but also indexed and searchable in a way that allows meaningful automated analysis (Wang et al., 2021). While OpenReview cannot prevent bias in peer review, it provides powerful tools for identifying it, enabling dialogue, and seeking remedies (Tran et al., 2020).

Despite the growing interest in open science, it has often been misunderstood (Ross-Hellauer and Görögh, 2019). Some scholars believe that full transparency causes problems for the conduct of peer review related either to the disclosure of the identities of the participants or to publishing the actual content of the reviews (Schmidt et al., 2018). Thus, the development of the different interpretations of what has been called 'openness' with varying levels of 'transparency' (Ross-Hellauer, 2017). These alternate strategies differ on whom is able to learn what about the identities of the authors, reviewers, and editors at which time in the review process (Baggs et al., 2008). Some authors and reviewers are reluctant to participate unless they can remain fully anonymous due to fear of harassment or retribution for negative reviews (Schmidt et al., 2018), a situation for which this attitude reflects an unwillingness to engage as peers on equal terms. However, full disclosure of both identities and content can bring about important ethical and societal benefits including accountability of, by, and for the peer review. As Aaron Swartz wrote in his 2008 Guerilla Open Access Manifesto, "Information is power. But like all power, there are those who want to keep it for themselves" (Swartz, 2008).

Openly and objectively debating both the merits and the deficiencies of other investigators' work has traditionally been an important duty for a scientist. However, this analysis with commentary and criticism must be done with civility, decency, and courtesy grounded in respect for truth in science and integrity in research. The principle of 'first do no harm' has been discussed explicitly by (C. Taswell, Donohue, M. T. Mastwyk, et al., 2018) (C. Taswell, Donohue, M. Mastwyk, et al., 2019) in the context of psychological health care, and can also be found implicitly (ie, without use of the classic phrase) in the reports by (T. G. Gerwing, A. M. A. Gerwing, Avery-Gomm, et al., 2020) (T. G. Gerwing, A. M. A. Gerwing, Choi, et al., 2021) in the context of professional peer review. If we *prioritize this principle of 'first do no harm' and thus commit to preventing the misconduct that can be hidden under the cloak of anonymity with anonymous peer review*, then only with open science and a completely open process with a reproducible methodology for open access data, open access results, and open peer review can we ensure that those who misuse or abuse their power are held both responsible and accountable for their actions. Only with open science that makes public both the process and the result, both of the original research and of the peer review, can we ensure that the scientific community can hold those who misuse or abuse their power accountable for their actions.

Peer Review of Peer Review

Peer review began originally with the simple practice of one or more persons of comparable education training and experience evaluating and critiquing the research work of another scientist. However, now that peer review has become a major battleground in the competition for research funding and employment, perverse incentives and biases motivate unfair practices by peer reviewers against their perceived competitors. Misconduct by authors, editors, reviewers, and publishers involves not only fabrication and falsification of research, but also idea-laundering plagiarism by authors and idea-bleaching censorship by editors in violation of the basic ethics of scholarly publishing (S. K. Taswell, Triggle, et al., 2020). We define *the scientific analysis of peer review with the phrase "peer review of peer review" to encompass the study and investigation of the state of the art and science of reproducible discourse and communications in peer review for scholarly research publishing* in the modern era.

Peer review of peer review should examine the underlying motives for the propagation of deceptions and lies that have been spread in the information wars, and study the efficacy of interventions to prevent the spread of wrongful information. Peer review of peer review should also examine those cases where scientific fraud and misconduct went uncorrected because of peer review failures or was otherwise not corrected and remediated for too long a period of time until after significant harm had already been caused by the spread of wrongful information. It also encompasses the analysis of those cases where peer review failed to identify scientific fraud or misconduct and analysis of the harm that resulted when publishers practiced 'willful disregard' by allowing such fraudulent works to persist in the scientific literature without retraction, expression of concern, or commentary otherwise calling attention to the previously published research with historical priority that was victimized by the primary, secondary or tertiary plagiarism wrongfully propagated by the publisher.

Whereas fabricated or falsified research may directly impede progress by wasting resources as researchers try to replicate results that never existed in the first place (Fang and Casadevall, 2011) (Avenell et al., 2019), plagiarism has the similar, though less direct effect of redirecting recognition, resources, and opportunities away from productive researchers, and instead, toward those who have misappropriated, plagiarized, or wrongfully taken credit for the work of others who were the original creative authors (Bejan, 2019). Just as professors in law schools study crimes and criminal behavior without the topic of crime being considered a taboo subject of investigation, so should scholars of the scientific process study peer review misconduct, plagiarism, and censorship cases without the topic of peer review analytics being considered a taboo subject of investigation.

To identify the scope of peer review of peer review, we must also provide operational definitions of the key concepts involved. In particular, of special importance because the word 'publication' has been used to refer to many different kinds of things, we define a 'publication' here as any document, manuscript, report, or article that has been made 'publicly available' for an audience of potential readers to access and read. If legal non-pirated access to the document requires payment of a fee by the reader, then it is deemed a fee-paid, reader-purchased, or subscriber-paid publication. If access to the document does not require payment of a fee by the reader, then it is a fee-free or open-access publication. With this simplified definition of a 'publication', words such as preprints and reprints also refer to documents that are publications because they have been made public, regardless of whether any fees have or have not been charged for either the reprint or the preprint, regardless of whether the reprints and/or preprints are distributed in softcopy or hardcopy, and regardless of whether the manuscript has been peer reviewed or not peer reviewed.

This definition of a publication also encompasses both preprints and reprints, in digital or printed form, whether peer-reviewed or not. In other words, we consider any document made available to the public in any form a publication, even when it is in what some would have considered the pre-publication phase according to past practices of traditional peer-reviewed publishing. However, our current definition better

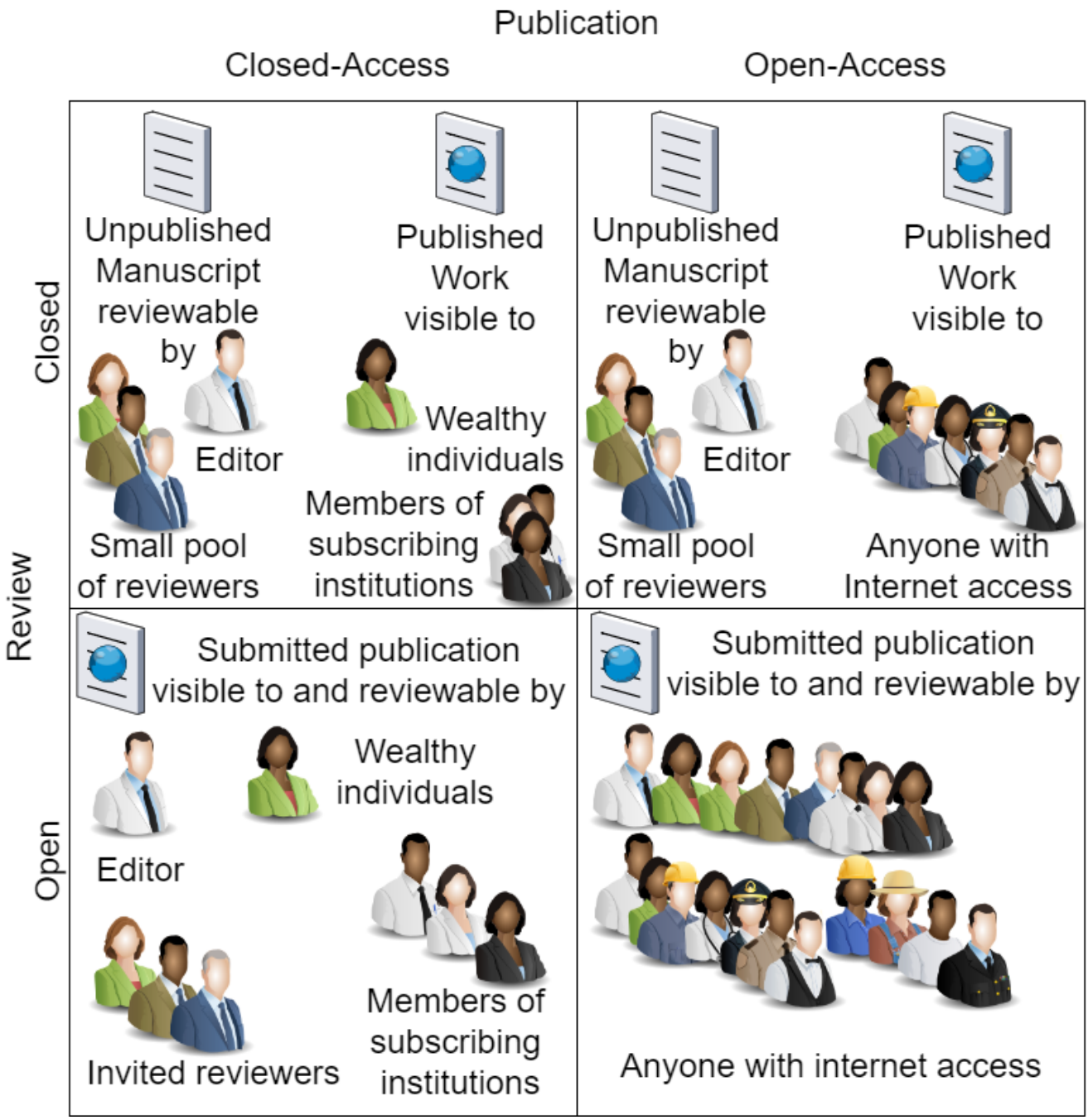

Figure 1: Four example models of publication. Under open access combined with open peer review, a scholarly work is able to both reach the widest audience and receive scrutiny from the largest pool of peer reviewers.

reflects the modern information landscape, where both professional researchers and the general public obtain most of their information online through a wide variety of websites and often have the option to post their own questions about and responses to a piece of writing (Ridley, 2012) (Fillmore, 2015).

Therefore, with the advent of online publishing (Fillmore, 2015) as a new way to reach a larger audience in faster time, and now with all of the diverse approaches to online peer review of preprints during what used to be called 'pre-publication', as well as online peer review of reprints during what used to be called 'post-publication', we adopt the simplified interpretation that a document becomes a publication as soon as it is published and made public in any form or format. In the past, publishers used paper printing presses and binders to produce physical objects such as books and journals printed with ink. Presumably, much of peer review was motivated by the desire to save costs in time and money when printing paper with ink on documents that did not meet quality standards. But now we have electronic internet web access to digital e-books and e-papers via devices from smartphones and tablets to laptop and desktop computers, and thus, we can expand the reach and access to published documents by both reviewers and readers of the intended audience. With online publishing, innovations in technology have changed how scientific knowledge can be produced,

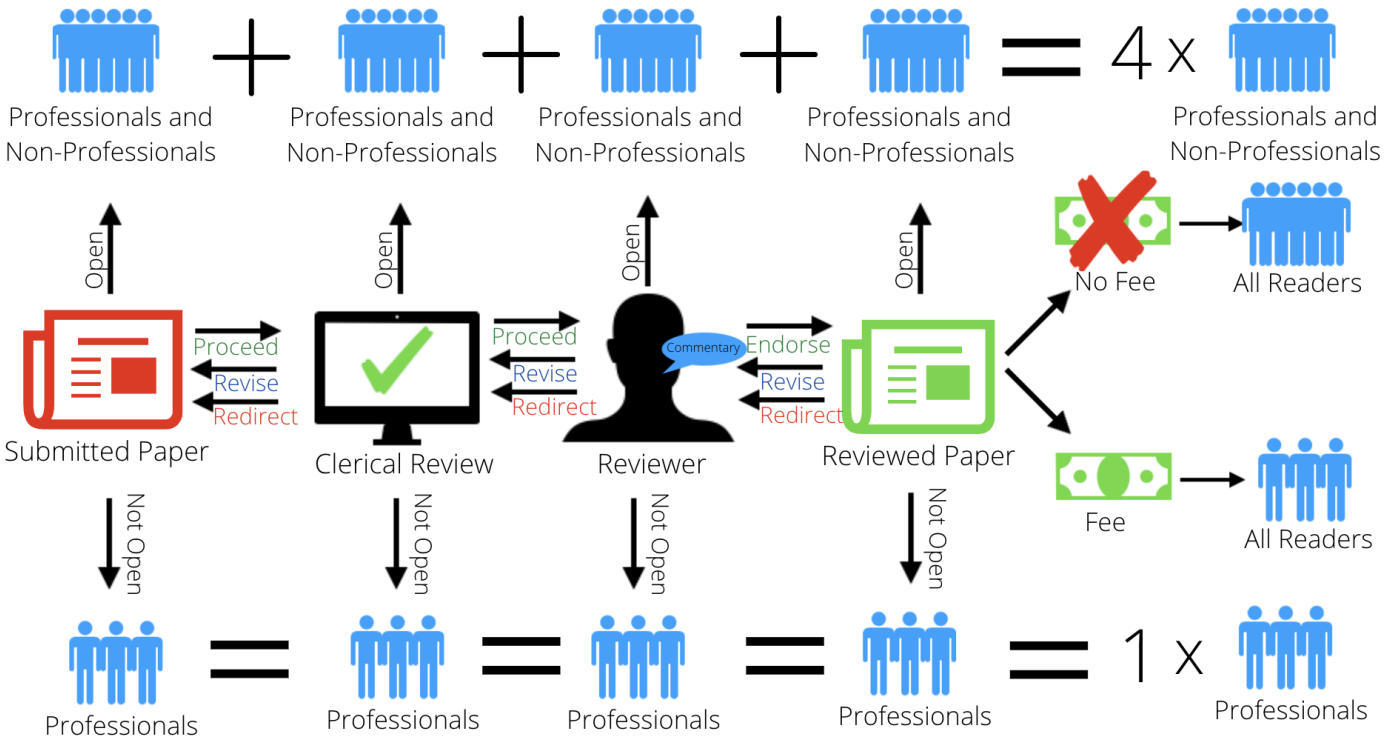

Figure 2: Open access increases potential audience of readers and reviewers, both professional and non-professional, while decreasing costs and eliminating paywalls. Relative sizes 4x and 1x are meant to suggest a larger number for open access and a smaller number for non-open access.

analyzed, and peer reviewed by an audience of readers and reviewers that includes both professionals and lay persons. Moreover, services such as Google Scholar and ResearchGate have created new portals for investigators to publish and promote their work (Ponte et al., 2017). Due to these changes with online publishing, many scientists have abandoned physical paper in favor of virtual paper, now preferring softcopy over hardcopy versions of their manuscripts.

Despite an improving democratization of the publication process, some publishers continue to impose an inappropriate and unjustified influence on scholarly research communications when their peer review process fails to retract and/or correct a paper that violates the requirements of reproducible science and publishing ethics. Thus, maintaining the preservation and dissemination of truthful information still requires the work of expert peer reviewers, who are free of financial personal and political conflicts of interest, and who abide by a respect for objective truth in experimental science and a respect for the published record of validated scientific literature. A document may become available online before the publisher officially endorses it. The publisher's own peer review process may be insufficient to identify mistakes, deceptions or lies in the document. These realities raise the question of where peer review should begin and end, or otherwise continue indefinitely after publication. However, with the increasing popularity of online digital publishing, the need for quality peer review based in objective truth with integrity remains essential both before and after 'publication'.

So what does 'peer review' represent now? And what words should be used for that peer review process? Therefore, we define the peer review process to include those sequential steps in a procedure by which a document undergoes analysis and revision with successive revised versions that result from discussions and deliberations in a conversation and dialogue between the authors, reviewers, editors, and publisher. This peer review process, if open and accessible to the public, may also include the participation of other persons not considered peers in the sense of professional colleagues but rather non-professionals who may be citizen scientists or lay persons. While many different variations on both open-access publishing and open-peer reviewing exist, let us consider and assume each in its most straightforward sense, with open-access publishing a phrase that means making a work available to anyone with internet access, and open-peer reviewing a phrase that means the publication has been submitted and made publicly available in a manner that is visible to and reviewable by all potential readers of a journal or other platform. Then we can identify four possible scenarios, out of which the combination of both open access and open review offers authors both the greatest possible reach and impact for their work and the most opportunity to receive feedback on their work from reviewers (see Figure 1).

This peer review process may occur before and/or after publishing the document and making it available to the public, and therefore, should not be conflated with a copy-editing process or a publication process. In fact, these definitions and interpretations imply that the peer review process should be considered independent of the publication process. Thus, they require some new language with vocabulary words to differentiate the separate processes for publication and for peer review, whether the peer review is open and transparent or not, and whether the publishing process occurs before and/or after the peer review process. We recommend moving away from use of phrases such as 'accept for publication' or 'reject for publication' because in the open peer review models, a manuscript may be published before it is *redirected, revised, or endorsed* (see Figure 2).

Figure 3: Four possible scenarios for identification of author and reviewer: Identified (✓) or Anonymous (?) where author writes manuscript and reviewer provides commentary.

Moreover, to illustrate the alternatives for disclosure of identities of the participants in open versus non-open peer review, we present another 2x2 truth-table for the four possible scenarios (see Figure 3) in which we refrain from use of any words some may deem pejorative such as 'blind'. Although we recognize the past use of terms such as 'single-blind' and 'double-blind', it is important especially in this post-truth era of information wars to begin using terms that communicate clearly and explicitly in a practical manner that is not metaphorical and that also avoids any use of potentially pejorative metaphors. Thus, we chose to use words such as 'identified', 'de-identified', and 'anonymous' as simple words that avoid metaphors and that are both easy to understand and difficult to misinterpret.

Editorial Review, Endorsement, and Retraction

Review

A process of publishing a manuscript traditionally begins when the author submits it to the publisher of a journal (Kelly et al., 2014). The editor-in-chief then assigns the manuscript to an associate editor and copyediting assistant, who perform initial checks and screening evaluations, which may include the use of software tools to compare the document with previously published papers to detect potential plagiarism (Kelly et al., 2014). Whereas most comparison software relies on lexical text matching, the ideal tool would also use semantic comparison and analysis to identify the unattributed use of ideas, even when the plagiarist has used different wording with paraphrasing in the absence of quote marks (Craig, Hong, et al., 2020). The editor can then redirect the manuscript back to the authors if serious concerns are found (Kelly et al., 2014). If not, the editor will then identify experts with appropriate domain-specific knowledge and invite them to peer review the research report (Kelly et al., 2014). Usually, reviewers do not receive financial compensation for the work of reviewing an article but instead volunteer their time and effort in order to contribute to progress in their field of science, give others the kind of fair review they themselves would like to receive, be among the first to read about important new discoveries, strengthen their working relationship with a publisher or editor, and report their review work to their employers or on their curriculum vitae, among other reasons (Kelly et al., 2014). Reviewing the manuscript requires reading it carefully, drawing on prior knowledge of the topic, commenting on the strengths and weaknesses of the work, and making a recommendation to accept the submission as-is, condition acceptance on completion of revisions, or reject it outright (Kelly et al., 2014). The guidance journals provide to peer reviewers varies widely, with some asking them to evaluate the novelty, significance, or impact of the manuscript, while others instructing them to focus on whether the authors conducted their research properly in accordance with the requirements of the scientific method. The text of the submitted manuscript may cycle through multiple iterations of requests for revisions by the reviewers and attempts by the authors to comply (Kelly et al., 2014). Ultimately, the editor will make a decision to accept or reject the manuscript for publication (Kelly et al., 2014). However, as displayed in Figure 2, we recommend use of the terms *proceed, redirect, revise, or endorse,* and are now using language with this vocabulary at the Brainiacs Journal.

Endorsement

The quotation ascribed to Voltaire, "perfection is the enemy of good" readily applies to peer review. Because it is often unlikely if not impossible for authors of a manuscript to address every question, request for revision, or critical objection expressed by peer reviewers, the managing editors must establish a standard with criteria clarifying when a research report has met sufficient quality for endorsement by the journal. Editors should communicate that standard to both authors and reviewers. An open peer review process that supports revisions throughout both the pre-publication and post-publication phase of the journal's activities and proceedings will encourage better collegial cooperation between all those who wish to advance progress in their community and field of scientific research. With this mindset and approach to scholarly communications, each published document becomes a living document that may progress through several versions. This improvement with revisions and corrections or enhancements with additional material including supplemental data can occur even after the editor has declared the most current dated version of the document 'good enough for now' and approved it with the status *endorsed* by the journal.

One suitable venue for this kind of continuing peer review has been preprint servers as well as other online data repositories, where au-

thors can publish their reports after a rapid automated check of the submission (Columbia University Irving Medical Center, 2021). While such platforms typically lack the name recognition of top-tier journals, the short turn-around time and open-access publication model allow a wider swath of readers to judge for themselves the merits of a work, enabling it to gain recognition through word-of-mouth on its own merits (Columbia University Irving Medical Center, 2021).

The COVID-19 pandemic has demonstrated the value of this faster, more open approach to sharing scientific knowledge, but has also demonstrated the need for a culture of rapid, open peer review that can keep up with it. With every day bringing news of more deaths from the pandemic, the urgency of the situation superseded the usual past concerns for profit and prestige. Journals made relevant articles freely available, and researchers posted what they had learned on preprint servers and searched for the latest discoveries of their colleagues (Vuong et al., 2022). The accelerated pace of research and collaboration lead to the development of a host of new vaccines at record-breaking speed but also allowed numerous carelessly conducted or under-powered studies to receive undue attention before the conventional peer review process could catch up to them, necessitating an aftermath of retractions (Vuong et al., 2022).

Retraction

Retraction of a published report has been used as a mechanism for correcting the literature and alerting readers. While journals vary in their criteria for and approach to retracting papers, the general goal has been to revoke the past acceptance of a published, peer-reviewed article and alert readers of any necessary correction to the record of scholarly literature (Wager and Williams, 2011). According to the Committee on Publication Ethics (COPE) Retraction Guidelines,

> "Editors should consider retracting a publication if: They have clear evidence that the findings are unreliable, either as a result of major error (e.g., miscalculation or experimental error), or as a result of fabrication (e.g., of data) or falsification (e.g., image manipulation); It constitutes plagiarism; The findings have previously been published elsewhere without proper attribution to previous sources or disclosure to the editor, permission to republish, or justification (i.e., cases of redundant publication); It contains material or data without authorisation for use; Copyright has been infringed or there is some other serious legal issue (e.g., libel, privacy); It reports unethical research; It has been published solely on the basis of a compromised or manipulated peer review process; The author(s) failed to disclose a major competing interest (a.k.a. conflict of interest) that, in the view of the editor, would have unduly affected interpretations of the work or recommendations by editors and peer reviewers"

(COPE Council et al., 2019). Coudert analyzed retraction notices from 2017 and 2018 in chemistry and materials sciences and found that the most frequent reason behind paper retractions was plagiarism, a type of misconduct, including both plagiarism of other authors' work and self-plagiarism, which accounted for 42% of cases (Coudert, 2019). Moylan *et al.* studied 134 retractions from BioMed Central that occurred between Jan 2000 and Dec 2015 (Moylan and Kowalczuk, 2016) and concluded that the most common reasons to retract were compromised peer review, plagiarism, and data issues. Grieneisen and Zhang surveyed 42 of the largest bibliographic databases from major scholarly fields and publisher websites and found 4,449 academic publications retracted between 1928 and 2011 (Grieneisen and Zhang, 2012).

Except in rare instances, journal retraction rates remain low, between 0.02-0.16%, of which only 20% were due to alleged research misconduct (Grieneisen and Zhang, 2012). Instead, the top 15 "repeat offenders" were collectively responsible for 52% of the world's retractions due to suspected research misconduct (Grieneisen and Zhang, 2012). These journals' significant retractions skewed overall data for years, countries, disciplines, and journals (Grieneisen and Zhang, 2012). Grieneisen and Zhang called for wider recognition of the fact that far more retractions occur due to errors rather than misconduct and thus a decoupling of retraction in such cases from damage to researchers' reputations (Grieneisen and Zhang, 2012). This view agrees with with Barbour *et al.* who are calling for a "no-fault" amendment system to replace retraction (Barbour et al., 2017). The low retraction rate in the above study (Grieneisen and Zhang, 2012) matches that mentioned in (Wager and Williams, 2011), where the retraction rate in Medline between 1988-2008 was 0.02%.

However, the low rate of retraction due to misconduct should not be cause for complacency. (Redman et al., 2008) and (Steen et al., 2013) reported changes in the behavior of both authors and institutions with concerns that there have been underestimates of retraction rates for research misconduct. (Redman et al., 2008) analyzed retractions from 1995-2004 from the National Library of Medicine's PubMed database. They explained that some retractions necessitated by research misconduct were instead reported as being due to inability to reproduce results. (Steen et al., 2013) analyzed multiple surveys and found that the rate of misconduct was much higher than the paper retraction rate. Their study concluded that journals have failed to retract numerous fraudulent papers. (Errami and Garner, 2008) used an automated search of 7 million biomedical abstracts and found that scientists frequently published duplicate articles without getting caught.

Such uncaught instances of research misconduct raise the question of what journals can do to better uphold standards of integrity. Although (Horbach and Halffman, 2018) argue that journals' use of peer review to identify fraudulent research is imperfect, peer review can serve as a key line of defense to catch potential fraudulent papers before their publication can cause harm by spreading false information. This concern involves potential harm for the author as well as for society at large, as the study by (Lu et al., 2013) with data from Web of Science shows that after retraction, authors face a sharp drop in citations of all their work, not only the retracted publication. An engineer in South Korea had 30 papers retracted by journals and was fired from his job due to violations of research ethics (Stern, 2018b). A graduate student in China was stripped of his Ph.D. after a dozen retractions due to misconduct (Marcus, 2018). A top physicist in India got into a fistfight with a colleague after journals retracted seven of his papers for plagiarism (Stern, 2017b). An Iranian university dismissed a researcher who had 26 papers retracted by publisher Elsevier on the grounds that he had suggested nonexistent peer reviewers and then submitted fake peer reviews through the email addresses he had provided to the publisher (Stern, 2017a) (Stern, 2018a).

Based on existing retraction data, (Horbach and Halffman, 2018) showed that the following measures in the peer review process seemed to be related to lower retraction rate: (a) keeping authors anonymous, (b) involving the wider community, (c) using digital tools such as plagiarism detection tools to assist review, (d) constraining interaction between authors and reviewers. But the authors acknowledged that they

did not understand why the double-blind review had a lower retraction rate and why augmented interaction between authors and reviewers appeared to be related to more retracted papers. The other two items, involving the wider community and using artificial intelligence tools to detect plagiarism, seem to make sense. Fear of these and other consequences often motivates authors to hide the truth rather than correct their mistakes (Vuong, 2020).

In an extreme case, it took the Lancet 12 years to retract Wakefield et al.'s 1998 article claiming a link between the Measles-Mumps-Rubella vaccine and autism on the basis of manipulated and wildly misinterpreted data, allowing Wakefield to maintain the veneer of being a legitimate scientist as he spread anti-vaccine propaganda (Eggertson, 2010). Use of scientific integrity checklists prior to publication as described by (S. K. Taswell, Triggle, et al., 2020) may offer a possible solution for shifting the burden of proof in a manner that could help reduce fraud and misconduct. With this approach requiring the use of scientific integrity checklists and commitment signatures by participants, the publisher mandates that authors, reviewers, and editors must affirm that they have conducted and completed specific steps of due diligence.

With such a checklist/signature mechanism and audit tracking in place, then at a later date the publisher could retract an endorsed article when proven with documentary evidence that any participant failed to abide by their commitment to integrity, reproducibility, and accountability. Such an approach may prove to be more actionable with greater compliance when the signature checklist is in place *a priori*, than without such a checklist resulting in situations *a posteriori* of alleging research misconduct after its occurrence has been discovered and exposed (S. K. Taswell, Triggle, et al., 2020). The *a priori* approach for checklists and signatures offers the additional benefit of requiring that publishers explicitly communicate to participants in the peer review process the standards they must meet (S. K. Taswell, Triggle, et al., 2020).

Peer Review Methods

Several recent works have reviewed different methods of peer review: (Barroga, 2020; Eisen et al., 2020; Ford, 2013; Hojat et al., 2003; Horbach and Halffman, 2018; Jubb, 2016; Kelly et al., 2014; Ross-Hellauer, 2017; Schmidt et al., 2018; Tennant, 2018; Tennant, Dugan, et al., 2017; R. Walker and Rocha da Silva, 2015; Ware, 2008). We believe that these "approaches, models, and policies for peer review" should be referred to simply as *methods* just like any other *scientific method*. Then we can emphasize that they should be subject to the same formal requirements and expectations for documentation and analysis as any other aspect of scientific inquiry in an empirical investigation and experimental report. Today, peer review is as much a part of the scientific process as is any biochemical assay or statistical test. For it to serve the needs of modern science, it must be subject to the same rigorous standards of detailed documentation and critical objective analysis.

The availability to each party of information about the other parties represents the aspect of the peer review process most central to the concept of open peer review. Some of the most commonly used terms for describing rules for who knows the identity of whom are "single-blind" and "double-blind", along with the more recently coined term "triple-blind" (Barroga, 2020). We mention these terms here as they remain the most commonly used vocabulary words in the lexicon of peer review for this purpose. However, for the rest of our report, we will follow the suggestion of (Ades, 2020) to avoid conflating physical impairments to vision with an absence of awareness of other persons' identity. Thus, we will use the terms "single-anonymous", "double-anonymous", and "triple-anonymous". In "single-anonymous" peer review, the reviewers know the identities of the authors, but the authors do not know the identities of the reviewers, while, in a "double-anonymous" arrangement, neither knows the identity of the other (Barroga, 2020). Whereas these definitions do not specify what information the editor has or what information either of the other two parties has about the editor, "triple-anonymous" review requires that the editor also be unaware of the authors' identities (Barroga, 2020).

From this summary, we can state that these terms do not always fully clarify who has what information about whom. If one assumes for simplicity that the three relevant parties are the authors, reviewers, and editors, that knowledge of the identity of one party by another is all-or-nothing, and that each party automatically knows the identity of its own members, then a full description would need to answer six questions: Do the authors know the reviewers? Do the authors know the editors? Do the reviewers know the authors? Do the reviewers know the editors? Do the editors know the authors? Do the editors know the reviewers? Consequently, one would need 2^6 (64) distinct terms to describe all the possibilities.

However, any system in which parties have asymmetric information about each other only makes sense if the trustworthiness of the parties is also asymmetric, that is, if some are above suspicion and suitably positioned to authoritatively identify error or wrongdoing on the part of the others. This assumption is at odds with the literal meaning of "peer" in "peer review", which implies that authors, reviewers, and editors should be equal partners in the endeavor. It is also at odds with the reality of peer review, wherein all three parties consist of fallible human beings with their own vested interests.

As such, the only two suitable options are those in which information is symmetric: complete concealment of the identity of each party from the others or complete disclosure of the identity of each party to the others. In the case of full anonymity, reviewers may still judge works unfairly due to factors such as confirmation bias or prejudice for or against a particular theoretical orientation (Hojat et al., 2003). Furthermore, anonymity can hide from the reviewers possible conflicts of interest on the part of the authors (Barroga, 2020). Of greatest potential harmful impact, anonymity violates the principle of *first do no harm* discussed above with the unchecked misconduct that *hides under the cloak of anonymity with anonymous peer review*. Fully open peer review offers a more robust solution to the problem in which instead of trying to eliminate all possible sources of prejudice or bias, it gives all participants in the review process, the reading public including citizen scientists, lay persons and other parties an opportunity to inspect the article, reviews, and editorial decision for bias and undue influence from conflicts of interest, then call for corrective action to remediate the mistakes that may have been published in the scientific report.

With respect to the many different aspects of formal protocols used for these peer review methods, perhaps the most discussed in the literature has been the identity of the participants often described as *single-blind, double-blind, or triple-blind*. However, as already discussed above, we do not support the use of such vague and imprecise metaphors because (a) they do not suffice for a more formally correct use of scientific vocabulary and terminology, and in practice, (b) they may fail to clarify who is *blind* to whom regardless of what may or may not be stated explicitly or otherwise redacted in the manuscript itself. Instead, we prefer the use of the more formally correct, meaningful, and descriptive terms *identified versus anonymous* to clarify the status of the participants as demonstrated in the examples summarized in Table 2 which addresses

Table 2: Descriptive labels for participants' identities in peer review protocols.

	Identified Author	Anonymous Author
Identified Reviewer	Double-Identified	Identified Reviewer
Anonymous Reviewer	Identified Author	Double-Anonymous

authors and reviewers but not editors.

Moreover, in the ethics community for advocacy of those with disabilities, (Ades, 2020) argues in a compelling manner that use of phrases such as *blind review* "perpetuates harmful stereotypes" and that refraining from use of such phrases does not represent "a form of vacuous political correctness or mere virtue-signaling." Instead, it provides a "meaningful message...[that] everyone should be included and treated fairly when applying to conferences and journals." We agree with (Ades, 2020) who concludes that "As a name for a process that evaluates submissions solely on merit, the phrase *blind review* should be dropped."

Single-Anonymous Reviews

Peer review with a single-anonymous protocol in the past has been implemented in practice almost always with identified-author anonymous-reviewer participants and only rarely (if ever as a matter of policy?) as anonymous-author identified-reviewer participants. The more common and prevalent practice in the past has been the protocol in which reviewers have known the identity of authors, but authors have not known the identity of reviewers. An argument advanced in the past for anonymous reviewers has been that the reviewer would be more likely to provide honest and critical feedback. Presumably, it would allow the anonymous reviewer to argue opinions and make decisions without fearing repercussions from the author's perceived influence or political control of the scientific field and community (Kelly et al., 2014). However, the main argument against reviewer anonymity has been that such anonymous reviewers, who review manuscripts on subjects similar to their own research, may be tempted to delay completing the review to publish their own data first, and may also be influenced by other forms of bias against their peers competing in the same field (Kelly et al., 2014).

These are just a few of the numerous problems with traditional peer review implemented with an identified-author anonymous-reviewer protocol. (R. Walker and Rocha da Silva, 2015) summarize these problems as delay in the review process, biased and unreliable reviews, failure to detect errors and fraud, a lack of transparency with disregard for unethical practices by reviewers, and a lack of recognition with incentives for reviewers to engage in advancing their field in a collaborative manner. (Teplitskiy et al., 2018) reported the prevalence of nepotism and "schools of thought" bias in peer review. The phrase "schools of thought" refers to different groups of researchers within a particular discipline who hold similar views on contested scientific topics. In a previous study by (Mahoney, 1977), the investigators asked 75 reviewers to referee manuscripts that described identical experimental procedures but reported positive, unfavorable, mixed, or no results, and found bias associated with different schools of thought. (Teplitskiy et al., 2018) recommended selecting reviewers from other schools of thought, and reviewers from more distant author peer networks.

Double-Anonymous Reviews

Peer review with a double-anonymous protocol requires that neither the author nor the reviewer be identified to the other party. (Tomkins et al., 2017) reported a study demonstrating the potential for bias in peer review with results favoring the double-anonymous protocol over the single-anonymous protocol. Their study separated reviewers into single-anonymous and double-anonymous groups. Results showed that the single-anonymous group (ie, anonymous-reviewer identified-author protocol) reviewed 22% fewer papers, of which the majority of papers chosen by reviewers were those with authors from prestigious universities and companies. This result demonstrated the influence of an author's institutional affiliation and how it played a significant role in the reviewer's decision. Peer review with the double-anonymous protocol can help combat this problem. However, it does not entirely remove bias because an author's writing style can often be recognized and their identity can be inferred and/or assumed (Okike et al., 2016).

Advantages of peer review with the double-anonymous protocol: Ideally, the reviewer would not be influenced by the author's identity or the author's institutional affiliation when reviewing the substantive material content of the manuscript solely on its own merits. This method may result in writing a more honest and fair review with scientific integrity. It may also provide authors greater opportunities with a fair chance to publish their research reports, regardless of their social status or institutional affiliation (Darling, 2014).

Disadvantages of peer review with the double-anonymous protocol: A reviewer can guess the identity of the author if the research field is small. Identification of the author by the reviewer may be more probable when, as is often the case, the author references their previous work in the manuscript. To eliminate this self-reveal by the author, presumably, the author could remove these references to their past work. However, such a tactic would violate the principle of discussing current research in the context of past research when writing a research report. Thus it would have an adverse impact on the quality of the literature review contained within the report for the requisite background summary as part of the introduction and statement of the research problem investigated (Okike et al., 2016).

Open and Transparent Reviews

Open peer review has grown in popularity since the turn of the 21st century, enabled by online web technology and electronic digital publishing. When first evaluated by (Ware, 2008), it was considered the least used category of peer review. However, adoption and implementation of various forms of open peer review have increased in use over the past decade (Barroga, 2020; Ross-Hellauer and Görögh, 2019; Schmidt et al., 2018; Tennant, Dugan, et al., 2017; R. Walker and Rocha da Silva, 2015; Wolfram et al., 2020). Open peer review, according to the open science movement, encourages reviewers to be open, honest, fair, and transparent (Wolfram et al., 2020). According to advocates, open peer review discourages incivility and disrespect, bias and discrimination, and, most importantly, peer review misconduct through violations of professional ethics and scientific integrity (Wolfram et al., 2020). Some journals have extended open peer review from the pre-publication phase to include also the post-publication phase (Eisen et al., 2020). Registered users at the journal can write public reviews of published papers. As a recent example important for public health, JAMA used

Table 3: Models and methods of peer review

Reference	Method
Hojat et al. (2003)	"The most common approach is the 'single-blind' review, in which the reviewer's identity is concealed from the author(s)", "The 'double-blind' review is another approach used by many professional journals...", "research suggests that making the reviewers' identity known to authors (open review)..."
Ware (2008)	"The norm in most academic disciplines, known as single-blind review..", "The main alternative is known as double-blind review...", "A newer approach to dealing with the criticisms of single-blind review is open peer review."
Ford (2013)	"signed review, disclosed review, editor-mediated review, transparent review, crowd-sourced review, pre-publication review, synchronous review, post-publication review"
Kelly et al. (2014)	"The peer review process is generally conducted in one of three ways: open review, single-blind review, or double-blind review."
R. Walker and Rocha da Silva (2015)	"Anonymity of authors: double-blind, single-blind; Anonymity of reviewers: anonymous, open"
Jubb (2016)	"Identifying reviewers and authors", "There are three main variants in identifying reviewers and authors: Single-blind, Double-blind, Open Review"
Ross-Hellauer (2017)	"...new traits or distinctions were introduced so that in the end, a schema of seven OPR traits was produced: Open identities, Open reports, Open participation, Open interaction, Open pre-review manuscripts, Open final-version commenting, and Open platforms ('decoupled review')"
Tennant, Dugan, et al. (2017)	"Single blind", "Double blind", "Models such as triple-blind peer review even go a step further...", "eponymous peer review has the potential to inject responsibility"
Ades (2020)	"It's time for conferences and journals to use phrases like 'anonymous' or 'identity-hidden' instead of 'blind review'."
Barroga (2020)	"Traditional peer review" with "triple-blind, double-blind, and single-blind review", "open peer review" with "review made public, reviewers and authors known"
Eisen et al. (2020)	"'publish, then review' model of publishing"

post-publication online commenting for all COVID19-related articles during the pandemic to maintain quality (Bauchner et al., 2020). F1000 Research takes this idea even further by making the review process itself fully open in addition to disclosing identities of participants. (Wolfram et al., 2020). Both reviewer identity and review comments are instantly accessible alongside the manuscript during review and revision (Wolfram et al., 2020).

Evaluating the *openness* of a peer review protocol can be assessed by answering the question: 'Who does what when?' More explicitly, who (author, reviewer, editor, publisher) decides to disclose what (participants' identities, manuscript cited references, manuscript content) when (during which step at what phase of the process) and whether participants have the opportunity to elect choices by opting in or out of options including the opportunity to change their choice at a later step in the process. Disclosing reviewers' identities could be mandated by the journal or optionally decided later by authors and reviewers. If the journal requires disclosure, revealing the reviewer's identity could happen when the reviewer accepts the invitation. Then the process becomes explicitly an open review from the beginning of any interaction between reviewer and author if identities are revealed. As an example, the publisher Frontiers allows interactions between reviewer and author, but does not disclose reviewers' identities during the review process. Frontiers discloses endorsing reviewers' identities alongside the paper at time of publication to acknowledge the reviewers' contributions, but does not disclose the identities of non-endorsing reviewers.

Some journals allow the author to decide whether they wish to learn reviewers' identities. Then the author is the person who effectively decides whether the review proceeds via a single-identified or double-identified protocol. Meanwhile, some journals allow the reviewer to decide whether they wish to disclose their identity, either upon accepting a review invitation or submission of the completed review. Then the reviewer is the person who effectively decides whether the review proceeds via a single-identified or double-identified protocol (Ware, 2008). Disclosing the content of review reports could be mandated by the journal or decided by authors or reviewers. A journal can choose to open all review reports as soon as the contents are available, maintaining the review process in a transparent manner as a library of live reviews. This approach would hold all involved parties accountable for their actions and their written words.

Ideally, the open peer review system would give all participants incentives to be objective, truthful, and civil (Kelly et al., 2014). This approach would also discourage plagiarism among authors and censorship from editors because all actions and words would be publicly accessible in an open library of documents (Kelly et al., 2014). However, some fear that more junior reviewers may be hesitant to raise different opinions when reviewing a more senior author's paper (Ware, 2008). Some scholars could simply refuse to review openly and decline to participate (Rowland, 2002). Indeed, we cannot ignore what has been called "reviewer fatigue" and the decline in participation of voluntary peer review (Breuning et al., 2015).

Reproducible and Accountable Reviews

We began this section on peer review methods by discussing the importance of changing our use of language concerning peer review

Table 4: Some examples of open peer review journals.

Journal	Publisher	COPE	Review Time
The BMJ	BMJ Publishing Group	Yes	8 weeks
eLife	eLife Sciences Publications	No	7 weeks
Giga Science	GigaScience Press	Yes	34 days
Journal of Statistical Software	American Statistical Association	No	1.5 years
Nature Communications	Nature Portfolio	Yes	10 days
ReScience C	ReScience Organization	No	5 months
Royal Society Open Science	Royal Society	Yes	30 days
SciPost Physics	SciPost Foundation	No	3-8 weeks
Semantic Web Journal	IOS Press Open Library	No	6 weeks

and supporting the calls for avoiding use of vague metaphors involving the word *blind*. Just as phrases like "single-anonymous" and "double-anonymous" fail to communicate explicitly who has what information about whom and when, so do the words "open" versus "closed", and "transparent" versus "opaque" unless clarified with a more detailed explanation of the process used for the peer review. As science advances, we expect researchers not merely to be open about their methods but to publish their data, algorithms, and both technologies and methodologies in sufficient detail that others can independently reproduce their work (Chen et al., 2019). Analogously, we also call for clarifying the use of our language concerning peer review that involves other metaphors such as *open versus closed* or *transparent versus opaque*. Similarly, we recommend that journals require the analysis provided in peer reviews be reproducible and that reviewers be held accountable for their assertions by requiring substantiation for assertions with either evidence, citations or both when those assertions involve scientific claims. When reviewers make assertions involving tone, tenor, and style of writing and use of language, requests for revisions should be made with demonstrated examples that can be followed by the authors in order to comply with the request. Fundamentally, we must debate whether it is *sufficient* to require *open and transparent reviews* in order to promote fair, just, and ethical peer review? Or will it be *necessary* to require *reproducible and accountable reviews* in order to promote integrity in research (S. K. Taswell, Triggle, et al., 2020) and truth in science (S. K. Taswell, Athreya, et al., 2021)? We should develop analytic methods for evaluating the reproducibility and concordance of multiple peer reviews completed independently by different reviewers adhering to the same methods and standards after having studied the prescribed approach and trained on a set of standard practice cases. We should continue to develop automated methods for evaluating adherence to scholarship standards such as *fair citation* (Craig, Ambati, Dutta, Kowshik, et al., 2019; Craig, Ambati, Dutta, Mehrotra, et al., 2019), reproducible research (Konkol et al., 2020), and *citational justice* (Kwon, 2022).

Most importantly, we should develop measures that assess the accountability of a publisher's management and supervision of peer review. Unfortunately, as described originally by (Pickett, 2020), and discussed by (S. K. Taswell, Triggle, et al., 2020), institutions often shirk their responsibility to investigate misconduct and to enforce sanctions or penalties against those who violate professional codes of conduct. COPE publishes a wide variety of educational materials, including case reports of alleged research misconduct, and provides a forum for discussion of ethical concerns, but it is has neither the ability to enforce the rules it advocates nor even any formal process for censuring parties who violate them, as described in (COPE Council, 2020) available as COPE Strategic Report 2020. However, the institutions of accused authors have a vested interest in avoiding the damage to their prestige that would come with acknowledging misconduct by their employees and thus a bias exists toward exonerating them or even ignoring accusations outright (Pickett, 2020).

Without an independent forum free of conflicts-of-interest in which impartial third parties can review the evidence for and against malfeasance, professional codes of conduct and ethical university policies have no practical relevance to the real world when they are not enforced. In the absence of enforced standards for truth, honesty, and integrity in scientific research duing the current post-truth era of information wars, mis-information, dis-information, anti-information, caco-information, and mal-information will continue to find their way into the published literature despite being peer reviewed (S. K. Taswell, Athreya, et al., 2021). Therefore, measures of accountability in peer review should be designed to encourage scientific cooperation and collaboration both internally within and externally across institutional boundaries while discouraging insularity, tribalism, and the harmful attitudes and behaviors that can be characterized by the realpolitik phrase *delay, obstruct, or destroy the competition*.

Manuscript Management Systems

Manuscript management systems, whether commercial software or non-commercial open source software, help editors, reviewers, and authors to track comments on and changes in documents. Table 5 lists some of these software systems for manuscript management. The process of selecting manuscript management software for a journal's peer review can become a painstaking effort (Salem et al., 2016). Some universities have designed and built their own software systems (Jacksi, 2015). Mature peer review software systems may have configuration options to choose single-anonymous, double-anonymous, or open peer review protocols. Kim et al. (2018) provide a systematic comparison of several manuscript management platforms: Berkeley Electronic Press (bepress™) from UC Berkeley, Open Journal Systems from the Public Knowledge Project, ScholarOne from Clarivate Analytics, Editorial Manager from Aries Systems, EVISE from Elsevier, ACOMS from Korea Institute of Science and Technology Information, JAMS from National Research Foundation of Korea, eSS@i from Medrang/Inforang, and EMS from M2community. (McKiernan, 2002) describes and compares several other systems: AllenTrack™ from Allen Press, Bench>Press™ from HighWire Press, EdiKit℠ (part of bepress™), the UK-based Electronic Submission and PEer REview (ESPERE) project, Journal Assistant™ from a company of the same name, Manuscript Central™ from ScholarOne℠, and Rapid Review™ from Cadmus Pro-

Table 5: Manuscript management system software with open source (OS) status.

Software Name	Organization	OS	Website
Ambra	Public Library of Science	Yes	plos.github.io/ambraproject
Annotum	Solvitor	Yes	annotum.org
BenchPress	Highwire Press	No	www.highwirepress.com/solutions/highwire-benchpress
Digital Commons	benchpress	No	bepress.com/products/digital-commons
Editorial Manager	Aries Systems	No	www.ariessys.com
EJPress	eJournal Press	No	www.ejournalpress.com/ejpress.html
Epress	University of Surrey	No	www.epress.ac.uk
Frontiers	Frontiers	No	www.frontiersin.org
Janeway	University of London	Yes	janeway.systems
Kotahi	Coko Foundation	Yes	https://coko.foundation/articles/kotahi...
Manuscript Manager	Manuscript Manager	No	www.manuscriptmanager.com
Open Journal Systems	Public Knowledge Project	Yes	pkp.sfu.ca/ojs
OpenReview	Univ Mass Amherst	Yes	https://openreview.net/about
ScholarOne Manuscripts	Thomson Reuters	No	clarivate.com/webofsciencegroup/solutions/scholarone
Scholastica	Scholastica	No	https://scholasticahq.com/

fessional Communications. However, as of 2022-06-10, the home pages for some of the projects mentioned, Bench>Press, Journal Assistant, and Rapid Review, are no longer available.

Salem et al. (2016) provide a working URL for Bench>Press: `http://portal.highwire.org/publishers/benchpress.dtl`. In the rest of this section, we summarize brief descriptions of some software tools not mentioned in the sources above.

Ambra is an open-source publishing platform that PLOS developed for specifically for open-access journals. While PLOS itself has ended development of the project and is encouraging new journals to adopt other systems, it still makes Ambra available under the MIT license, and 8 PLOS journals still use it (`https://plos.github.io/ambraproject/`, retrieved 2022-06-10).

Annotum builds on the popular WordPress content management system that supports the National Library of Medicine's (NLM) Journal Article Tag Suite (JATS) and conformance to the NLM's document type description with a streamlined workflow inspired by the earlier *PLOS Currents* (Leubsdorf, 2011).

Digital Commons is bepress's hosted solution, mainly marketed to universities and supporting not only a variety of journal publishing models but also management of research data, conference submissions, and student projects, among other uses (`https://bepress.com/products/digital-commons/`, retrieved 2022-06-10). For accounts of specific user experiences with different aspects of this system, see (Daly and Organ, 2009), (Manninen, 2018), and (W. Walker and Keenan, 2015).

EJPress offers a full-service model wherein eJournalPress project managers work with the client to customize the EJPress-based site to fit the needs of each individual journal (`https://www.ejournalpress.com/ejpress.html`, retrieved 2022-06-10).

Electronic Publishing Resource Service (epress) offers another hosted solution with pricing based on the number of article submissions, which the client can purchase in blocks in larger blocks to achieve a lower cost per article. For example, whereas the smallest block is 12 articles at a cost of 10.50 GBP per article for a total of 126 GBP, the largest block is 1000 articles at 5.50 GBP per article for a total of 5500 GBP (`https://www.epress.ac.uk/`, retrieved 2022-06-10).

Janeway is an open-source (AGPL v3) project that the Centre for Technology and Publishing at Birkbeck, University of London developed for scholarly publishing. Its core design principles are to make the source code easy to understand and modify, to selectively regression test to check that new updates do not introduce new security holes, to prioritize fixing any reported security bugs, and to never introduce support for paywalls, thereby keeping all journals that use Janeway open-access (`https://janeway.systems/about`, retrieved 2022-06-10).

Manuscript Manager, like epress, offers a hosted solution with multiple tiers based on the total number of manuscripts to be hosted. In their case, the prices range from 20 USD per manuscript for 10 to 8.5 USD per manuscript for 1000 (`https://www.manuscriptmanager.com/`, retrieved 2022-06-10).

Computing Software and Artificial Intelligence

With the number of manuscript submissions growing, the corresponding demand for peer review has increased dramatically (Haederle, 2020). This surge was especially evident during the recent COVID-19 crisis in 2020, as researchers increasingly turned to preprint servers to meet the urgent need to share new knowledge (Haederle, 2020). The trade-off for bypassing the lengthy peer review process was a lack of quality control, meaning that readers could never be sure of the veracity of what they were reading (Haederle, 2020). Some commentators, especially those working in the field of artificial intelligence, predict that automated systems will soon be able to provide faster, impartial initial assessment of the quality of new reports (Haederle, 2020).

Even if these automated systems lack the insight and nuanced, context-aware understanding of an experienced human reader, they can still apply preliminary scans for plagiarism, grammatical mistakes, and incorrect formatting prior to human peer review (Checco et al., 2021) and play an important role in the peer review process (S. K. Taswell, Triggle, et al., 2020) (Schulz et al., 2022). The study published by (Checco et al., 2021) demonstrated that a machine learning algorithm trained to predict reviewer scores based on superficial features, such as readability score and average word length, could predict the scores of human reviewers with a median error of 0.79 points on a 10-point scale (Checco et al., 2021). The authors proposed that such algorithms could be useful as tools for performing initial vetting of submissions but also suggested that the high accuracy reflected a bias among human

Table 6: Manuscript management software with AI/ML.

Name	Developer	Features
EVISE	Elseviers	Checks for plagiarism
		Checks for conflicts of interest with the reviewer
		Workflow with authors, reviewers, and editors (Stockton, 2017)
AIRA	Frontiers	Provides recommendations about language, figures, plagiarism
Scholarcy	Scholarcy	Creates summaries of the paper
		Flashcard format
StatReviewer	Springer-Nature	Checks for complete and accurate statistical data (Stockton, 2017)
		Checks that statistics and methods are accurate (Checco et al., 2021)
ScholarOne	ScholarOne	Uses NLP and ML to analyze manuscripts
		Summarizes the paper with key concepts

reviewers toward judging papers based on effective use of language rather than based on the merits of the research itself (Checco et al., 2021). They also expressed concern that seeing a score generated by a purportedly objective AI that was actually trained on the judgments of biased humans could in turn reinforce those same biases in other human reviewers (Checco et al., 2021).

While humans may manifest prejudices when engaging in peer review, computers should be able to view every manuscript through the same lens applying the same algorithm in a uniform impartial manner (Checco et al., 2021). However, despite progress in natural language processing (NLP), machines cannot yet achieve the level of sophisticated comprehension of language that comes effortlessly to most humans (Checco et al., 2021). For the near future, computing software will be more beneficial in assisting the peer review process rather than replacing it. Some possible services of ML/AI include reviewer selection, document processing automation, and pre-review scanning (Sheridan, 2017). Using ML/AI before peer review to scan for plagiarism, look up cited sources, validate claims, and recommend human reviewers could substantively reduce the time between submission and publication (Checco et al., 2021). Table 6 lists some manuscript management systems that incorporate AI/ML.

Motivating and Maintaining Peer Review

In order for peer review to fulfill its role in scholarly research publishing, effective and efficient methods should be advanced not only to maintain this practice, but to promote and improve it. These methods should relate to both the motivational and practical aspects of peer review. One way to spare human reviewers from the more tedious, time-consuming aspects of peer review has been to automate the process with software (Heaven, 2018). Recent adoption of computing software that can better manage pre-review of submitted manuscripts to ensure that the documents meet basic formatting requirements, topic scope requirements, and research conduct requirements, will enable scholars to focus their time spent on peer review addressing those issues not readily appraised by the use of automated software algorithms. As an example of progress on this matter, (Craig and C. Taswell, 2022) have recently introduced the use of both inclusion and exclusion criteria for automating adherence to scope of conference calls for papers. This hybrid approach combining both human and machine evaluations will enable peer review to be more productive and viable in the future. Possible applications also include automated checks of claims and statistical analysis of data which should help detect unintentional mistakes and errors (Heaven, 2018). These discrepancies can often be missed by the reviewer, especially when they concern seemingly minor details or are embedded in a longer report (Heaven, 2018). Thus, with the use of new technology, peer review can be become more effective and efficient, and therefore, more maintainable and sustainable into the future of scientific research publishing.

The more difficult challenge in peer review remains the debated question about what could or should motivate and incentivize human reviewers to continue reviewing manuscripts in the mindful, nuanced, and fully context-aware manner that only humans can perform. We consider this concept of motivation as it relates to the fields of ethology for animals and behavioral psychology for humans. Behavioral psychology explains that human behavior changes occur in a contextual environment when new responses are evoked in reaction to events in time and/or changes in situation (Rivier University, 2022). Two basic categories of contributing factors that elicit changes are often called incentives (positive reinforcement) and disincentives (negative reinforcement), or more colloquially, rewards and punishments. When applied to peer review in the contextual environment of the current post-truth information wars, the abandonment of investigation of misconduct violations, and the apparent aversion against enforcement of professional codes of conduct by institutions' integrity offices, the only practical alternative remains the use of positive incentives over negative disincentives. Animal trainers have long known that rewards are a more effective tool for shaping behavior than are punishments (Castro et al., 2020). Indeed, the training of animals is now regarded as abusive and harmful if it is associated with pain, injury, and punishment rather than treats, food, and positive rewards (Castro et al., 2020). Behavioral psychologists have shown that the same applies to humans and that positive reinforcement is vital to successful personnel management (Kamery, 2004), suggesting that reviewers will become more active participants engaged in peer review if and when motivated with sufficiently appropriate positive rewards (Johnston, 2015).

Are the currently available positive incentives (as well as any negative disincentives that may exist in some venues) appropriately aligned and compatible with the powerful dynamics of the political, social, psychological, and financial interests now prevalent in the current post-truth information wars? As long as research misconduct including fraud, fabrication, falsification, idea-laundering plagiarism by authors, and idea-bleaching censorship by editors (S. K. Taswell, Triggle, et al., 2020) remains as prevalent as it does exist in today's information wars, then peer review with quality, truth, and integrity will also remain a difficult and challenging endeavor for all parties involved in scholarly research publishing. In the current climate of mistrust of authority and political

polarization, especially with the now prevalent and perverse misuse of "dark transparency" as a rhetorical sleight of hand in political discourse (Biagioli and Pottage, 2022), subjective rewards of praise for the impression of a job well-done simply no longer suffice as reliable forms of positive reinforcement (S. K. Taswell, Triggle, et al., 2020). Therefore, we recommend a renewed focus on prioritizing other positive incentives for reviewers that can be easily implemented, become readily and widely available, and remain amenable to monitoring with objective metrics. In other words, peer reviews should be citable references that are linked directly to the scientific report reviewed, and more importantly, that should be easily countable as measures of a reviewer's participation and productivity as a quality reviewer. Thus, we should also develop metrics that assess the quality and expertise of the content published in these peer reviews of scholarly communications.

Past literature reviews on the topic of peer review have discussed this recommendation of publishing reviews by identified reviewers (Jubb, 2016; Ross-Hellauer, 2017; Ross-Hellauer and Görögh, 2019; Schmidt et al., 2018; Tennant, Dugan, et al., 2017; R. Walker and Rocha da Silva, 2015). But none of these past discussions have emphasized the critical importance of peer reviews as independent citable references that can be linked and crossreferenced, measured and evaluated with public, open, fair, transparent, and just *peer review of peer review* in support of *reproducible and accountable reviews*. We demonstrated an example of this practice at the Brainiacs Journal with the research report "Truth in Science" by S. K. Taswell, Athreya, et al. (2021) in which the Acknowledgments section thanks those reviewers who preferred to be identified in that manner, and more importantly, for which some of the reviews appear as separately published commentaries (see Triggle (2022) and Wolfram (2022)). Finally, we recommend that these peer reviews, when published as independent citable references, be labeled as *Discussions* or *Commentaries* in order to distinguish them more readily from literature reviews.

Conclusion

Defending, preserving, and protecting truth in science, integrity in research, and improving the quality of scholarly publishing should be more important than increasing the quantity of scholarly publications. Peer review must play a critical role in protecting the integrity of scientific research against the increasing prevalence of sham science with research fraud and misconduct in the post-truth era of information wars and the increasing rates of retractions of scientific publications. Adopting a 'see no evil, hear no evil, speak no evil' posture that ignores these problems will not solve them. Instead of abandoning professional codes of conduct and denying responsibility for investigation of fraud and misconduct, we must promote a renewed emphasis on the important role of reproducible and accountable peer reviews in the defense of integrity in scientific research. We should re-align political, social, psychological, and most importantly, financial incentives to foster greater communication, cooperation, and collaboration in quality peer review in support of the open science movement with open access, open peer review, fair citations, and citational justice. We can do so by elevating the status and prestige of the art and science of peer reviews by publishing them as citable references and analyzing them with computer software technology, machine artifical intelligence, and the human peer review of peer reviews.

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