Science
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Peer Review in Practice and Evolution at *Science* magazine

Brad Wible
Senior Editor
Science
Washington, DC, USA

PEERE, Budapest
14 Oct 2014

American Association for the Advancement of Science

Founded in 1848

Non-profit membership society

World's largest general-science society

Serves 10 million individuals through primary membership and affiliations with ~260 scientific societies and academies

Mission: *"to advance science and serve society"*

publication of *Science* journals annual meetings
public outreach international scientific
cooperation policy advocacy educational programs

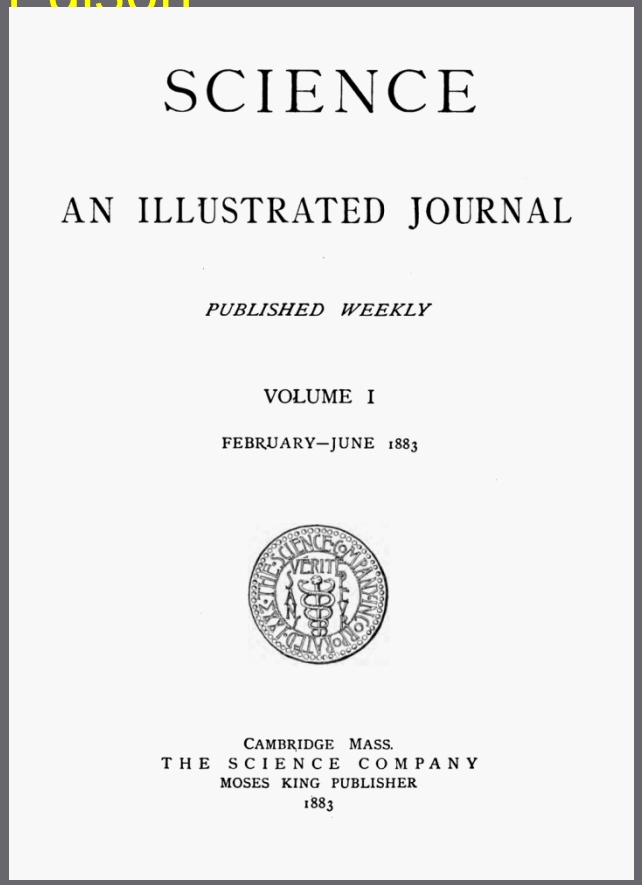
press relations public understanding

Science

Editor-in-Chief, Marcia McNutt

Founded in 1880

seed money from Thomas Edison



SCIENCE

AN ILLUSTRATED JOURNAL

PUBLISHED WEEKLY

VOLUME I

FEBRUARY—JUNE 1883

CAMBRIDGE MASS.
THE SCIENCE COMPANY
MOSES KING PUBLISHER
1883

research, news, commentary

readership > 1 million

35-40% corresponding authors non-U.S.

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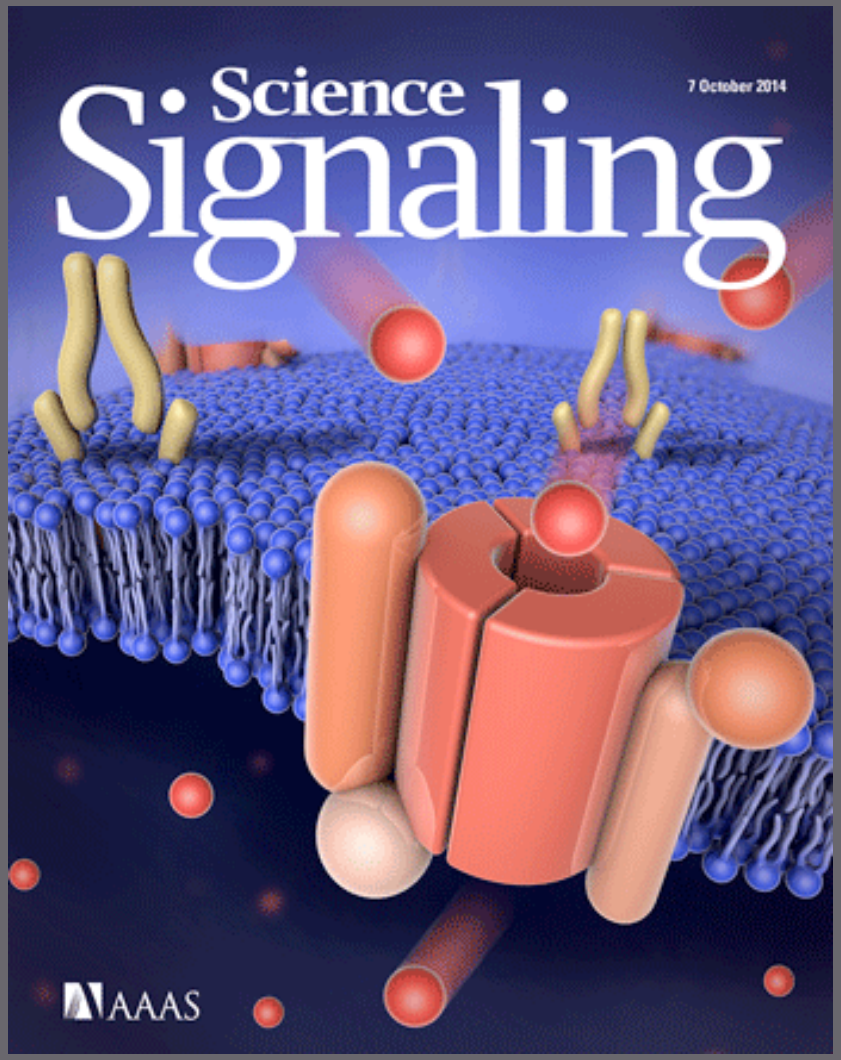
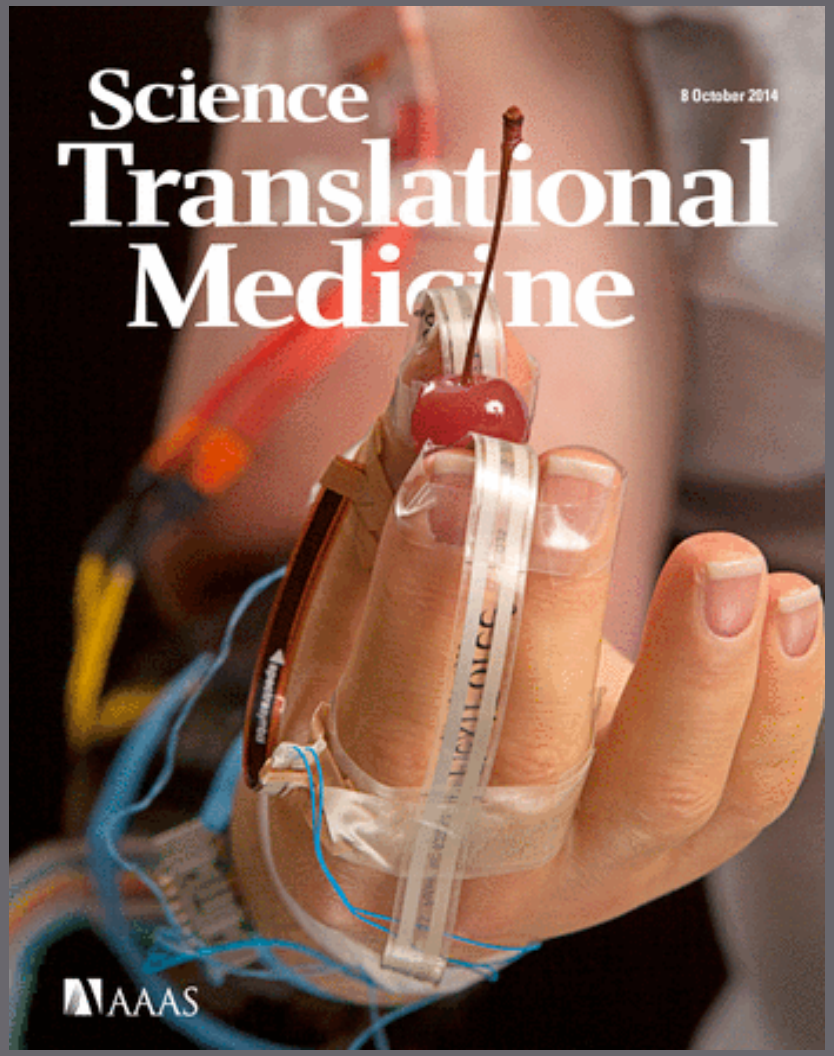


Science Signaling, 2008



Science Translational Medicine, 2009

Science Advances, 2015

Open access

Digital only

Marcia McNutt is Editor-in-Chief of *Science*.

Alan I. Leshner is Chief Executive Officer of AAAS and Executive Publisher of *Science*.

EDITORIAL

Science Advances

THE MISSION OF THE NONPROFIT AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS), the publisher of *Science*, is to advance science for the benefit of all humankind. *Science* contributes to that mission by communicating the very best research across the full range of scientific fields to an extremely broad international audience. The research enterprise has grown dramatically in the past few decades in the number of high-quality practitioners and results, but the capacity for *Science* to accommodate those works in our journal has not kept pace. Its editors turn away papers that are potentially important, well written, of broad interest, and technically well executed. Although other journals provide publishing venues for more papers, many authors still desire to be published in *Science*, a journal known for its selectivity, high standards, rapid publication, and high visibility.

To help meet this need, as well as expand the current content of *Science* so as to include even more diverse topics in science, engineering, technology, mathematics, and the social sciences, AAAS will be launching, in early 2015, a digital-only journal, *Science Advances*. Like *Science*, this new publication is designed to encourage transformative research and serve a wide readership. Our view at AAAS is that science is becoming more integrated and interdisciplinary, and therefore we prefer to provide one additional broad journal rather than a number

The science publishing landscape

>16,000 journals (Thomson Reuters)

Specialist disciplinary research

Review journals

General multidisciplinary research

Hybrid research/news/commentary

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Changing landscape of science journal/research publishing

- Data increase
- Reader/user habits
- Online possibilities
- Social media/blogs etc
- Open access
- Copyright

Science's Mission Statement

Science seeks to publish those papers that are most influential in their fields and that will significantly advance scientific understanding. Selected papers should present novel and broadly important data, syntheses, or concepts. They should merit the recognition by the scientific community and general public provided by publication in *Science*, beyond that provided by specialty journals.

Peer Review

- maintain standards
- improve scientific papers
- shared societal responsibility among researchers, reviewers, and publishers
- fundamental to integrity and accountability of science

Peer review in *Science*: Editorials

EDITORIAL

Raising the bar

Numbers. Lots and lots of numbers. It is hard to find a paper published in *Science* or any other journal that is not full of numbers. Interpretation of those numbers provides the basis for the conclusions, as well as an assessment of the confidence in those conclusions. But unfortunately, there have been far too many cases where the quantitative analysis of those numbers has been flawed, causing doubt about the authors' interpretation and uncertainty about the result. Furthermore, it is not realistic to expect that a technical reviewer, chosen for particularly when sophisticated approaches are needed. But even when taking added precautions, no review system is infallible, and no combination of reviewers can be expected to uncover all of the ways in which the interpretation of results may have gone wrong. In particular, it is difficult for reviewers to detect whether authors have approached the study with a lack of bias in their data collection and presentation.

I recall a study that I conducted years ago involving a global analysis of some oceanographic features that I was modeling to understand the rheology of oceanic

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Reproducibility

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SCIENCE ADVANCES ON A FOUNDATION OF TRUSTED DISCOVERIES. REPRODUCING AN EXPERIMENT is one important approach that scientists use to gain confidence in their conclusions.

Peer review in *Science*: Commentary

Science 4 October 2013:
Vol. 342 no. 6154 pp. 80–82
DOI: 10.1126/science.1243622

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Read Full Text to Comment (0)

POLICY FORUM

Scholarly Communication: Cultural Contexts, Evolving Models

Diane Harley

Science 3 January 2014:
Vol. 343 no. 6166 pp. 30–31
DOI: 10.1126/science.1245317

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Read Full Text to Comment (0)

POLICY FORUM

SOCIAL SCIENCE

Promoting Transparency in Social Science Research

E. Miguel[1,*], C. Camerer[2], K. Casey[3], J. Cohen[3], K. M. Esterling[4], A. Gerber[5], R. Glennerster[6], D. P. Green[7], M. Humphreys[7], G. Imbens[3], D. Laitin[3], T. Madon[1], L. Nelson[1], B. A. Nosek[8,9], M. Petersen[1], R. Sedlmayr[10], J. P. Simmons[11], U. Simonsohn[11], M. Van der Laan[1]

± Author Affiliations

Peer review in *Science*: News

The Web's Faceless Judges

PubPeer is the latest forum for free-ranging discussion of published papers. It can only succeed, say its anonymous founders, if participants are able to keep their identities hidden

"I think it's going to be very hard to stay anonymous forever."
—PUBPEER FOUNDER

Who's Afraid of Peer Review?

A spoof paper concocted by *Science* reveals little or no scrutiny at many open-access journals

On 4 July, good news arrived in the inbox of Ocorrafoo Cobange, a biologist at the Wassee Institute of Medicine in Asmara. It was the official letter of acceptance for a paper he had submitted 2 months earlier to the *Journal of Natural Pharmaceuticals*, describing the anticancer properties of a chemical that Cobange had extracted from a lichen.

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One might have expected credible peer review at the *Journal of Natural Pharmaceuticals*. It describes itself as "a peer reviewed journal aiming to communicate high quality research articles, short communications, and reviews in the field of natural products with desired pharmacological activities." The editors and advisory board members are pharmaceutical science professors at universities around the world.

The journal is one of more than 270 published by Medknow, a company based in Mumbai, India, and one of the largest open-access publishers. According to Medknow's website, more than

ILLUSTRATION: DAVID PLUNKERT

Peer review in *Science*: Research

Race, Ethnicity, and NIH Research Awards

Donna K. Ginther,[1]* Walter T. Schaffer,[2] Joshua Schnell,[3] Beth Masimore,[3] Faye Liu,[3] Laurel L. Haak,[3] Raynard Kington[2]†

We investigated the association between a U.S. National Institutes of Health (NIH) R01 applicant's self-identified race or ethnicity and the probability of receiving an award by using data from the NIH IMPAC II grant database, the Thomson Reuters Web of Science, and other sources. Although proposals with strong priority scores were equally likely to be funded regardless of race, we find that Asians are 4 percentage points and black or African-American applicants are 13 percentage points less likely to receive NIH investigator-initiated research funding compared with whites. After controlling for the applicant's educational background, country of origin, training, previous research awards, publication record, and employer characteristics, we find that black applicants remain 10 percentage points less likely than whites to be awarded NIH research funding. Our results suggest some leverage points for policy intervention.

Peer review in *Science*: Special Issues

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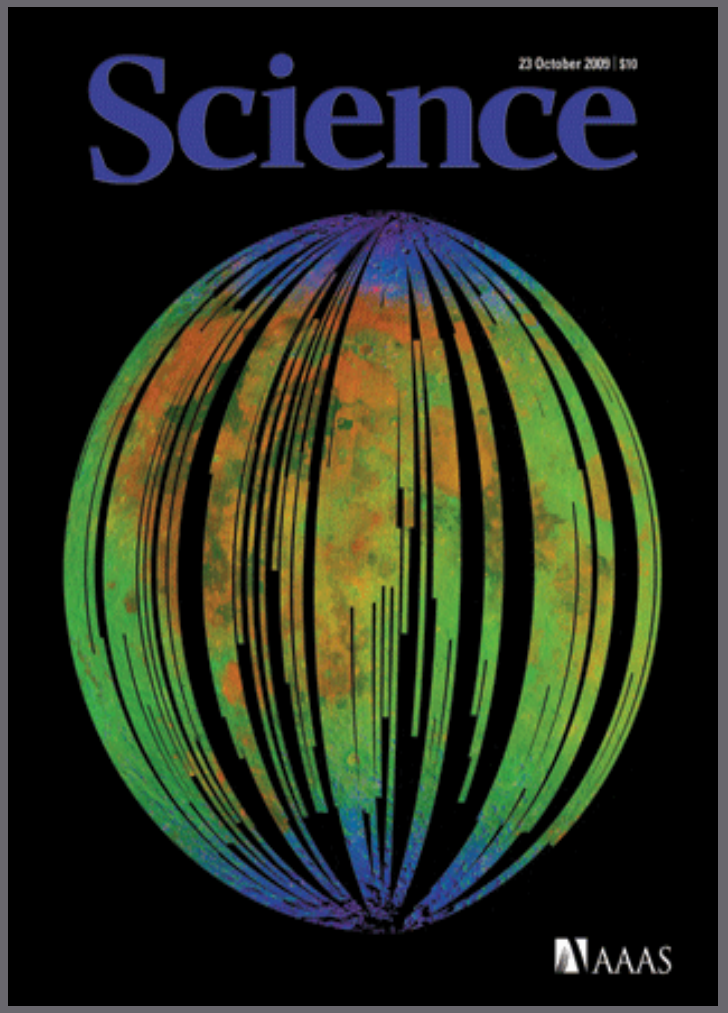
The review process: who is involved?

Internal

- Staff Editors

External

- Board of Reviewing Editors
- Referees



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1200 New York Avenue, NW, Washington, DC 20005
Bateman House, 82-88 Hills Road, Cambridge, UK CB2 1LQ

30 professional editors

PhD and post-doctoral experience

Maintain connections with field

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Board of Reviewing Editors (BoRE)

196 members

56% US, 36% Europe, 5% Asia

65% bio, 26% physical, 9% social/behavioral

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Board of Reviewing Editors (BoRE)

48 hour feedback

Are scope, focus and results appropriate for *Science* versus more specialized journal?

Suggest referees

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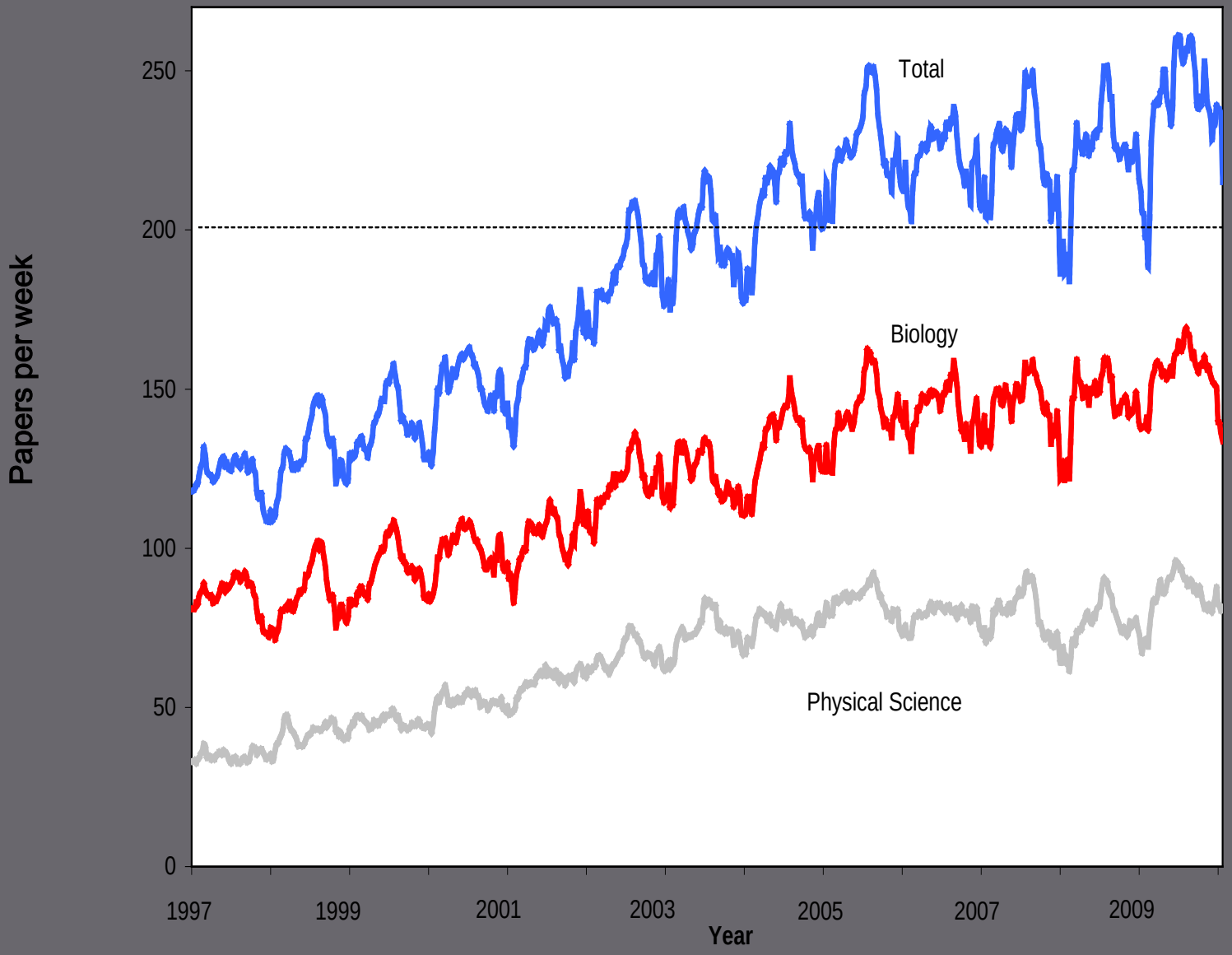
Original research submissions 1997 - 2010

smoothed w/ an 8 week running avg



2013 Manuscript Overview

Total manuscripts: 12163

- Per editor: 400-500
- To BoRE: 72%
- To review: 19%
- Published: 6%

Average time to complete review:

- round 1: 25 days
- round 2: 10 days

Submission to post-review decision: 49 days

Submission to accept: 99 days

Selecting referees

- Editors' experience
- Board suggestions
- Database records
- Web/literature searches
- Suggested/excluded lists from authors
- Variety of experience levels, backgrounds, institutions, nationalities

what editors ask of referees (1);

- Give a brief synopsis of the paper
- Analyse the quality of the experiments/observations
- Analyse the validity of the analysis/interpretation
- Distinguish from related publications or prior work
- Discuss the paper's significance and likely impact

what editors ask of referees (2);

to rate the manuscript
- Excellent & Exciting
- Above Average
- Too Specialized
- Mediocre/Poor

to recommend whether the submission should be
- published without delay
- published after minor revision
- re-reviewed after revision
- rejected

referees are given opportunity to provide confidential comments to editor

Conflicts of interest for referees

Friends (or rivals)

Co-workers, collaborators, mentor/student

Financial and consulting affiliations

Intellectual loyalty to or against the theories

Three Rs for Referees

Respect confidentiality/anonymity

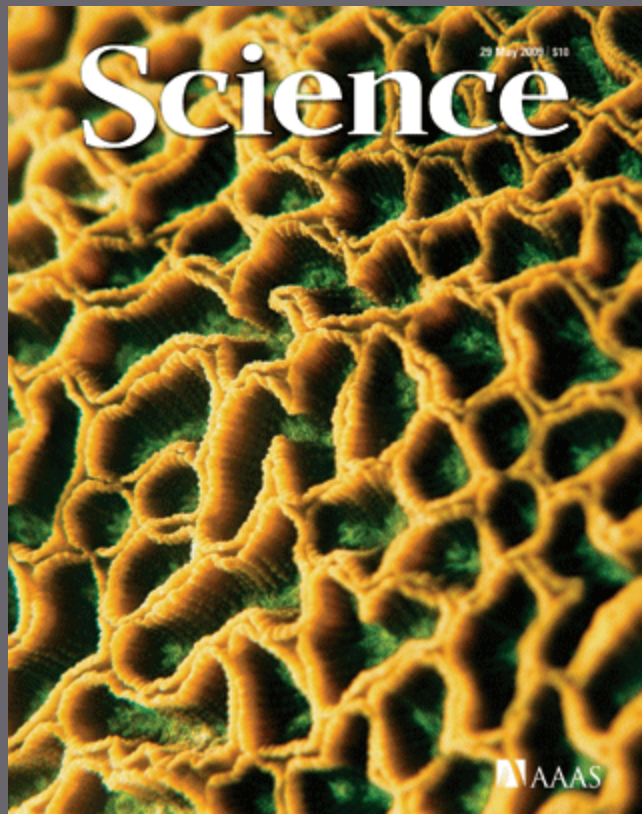
- do not distribute the manuscript
- do not use the knowledge
- you gain from the manuscript

Respond promptly

- within two weeks

Refrain from emotional bias

- respect the author's independence



Peer reviewer responsibilities toward authors include:

Provide written, unbiased feedback
- in a timely manner
- on scholarly merits and scientific value of work
- document basis for opinion

Strength of writing
- clear, concise, and relevant
- composition, scientific accuracy, originality, interest to readers

Avoid personal comments or criticism

Maintain confidentiality of the review process
- no sharing
- no discussing with third parties
- no disclosing the information in the reviewed paper

(Council of Science Editors 2009)

Peer reviewer responsibilities toward editors include (1):

- Notifying the editor immediately if unable to review in a timely manner and providing the names of potential other reviewers
- Complying with the editor's written instructions on the journal's expectations for the scope, content, and quality of the submitted work
- Providing a thoughtful, fair, constructive, and informative critique of the submitted work
- Determining scientific merit, originality, and scope of the work; indicating ways to improve it; and recommending acceptance or rejection using whatever rating scale the editor deems most useful

(Council of Science Editors 2009)

Peer reviewer responsibilities toward editors include (2):

- Noting any ethical concerns, such as any violation of accepted norms of ethical treatment of animal or human subjects or substantial similarity between the reviewed manuscript and any published paper or any manuscript concurrently submitted to another journal

- Alerting the editor about any potential personal or financial conflict of interest and declining to review when a possibility of a conflict exists

- Refraining from direct author contact without the editor's permission.

(Council of Science Editors 2009)

The ideal referee:

- Good judgment
- Fully familiar with the relevant literature
- Reasonable expectations
- High standards
- A broad point of view
- Technical expertise in the discipline
- Willingness to learn from the author
- Ability to explain reasons for recommendations

How many referees?

Until recently, 2 was the norm

Now increasingly 3 or more, because:

- More interdisciplinary papers
- More Supplemental Material
- Referee disagreement
- Incomplete review

(and we may need to approach 5-10 to find 3)

How many rounds of review?

Decision to reject usually takes one round of review.

Revised papers are often sent to referees again, especially if they incorporate new data or the referees have asked to see again.

Main principles of selection

- Quality of research
- Scope
- Interest
- Novelty

More than incremental?

- Answer to a longstanding question
- Significant leap forward
- Different way of thinking
- Important application

Common reasons for rejecting a manuscript

Too small an advance

Narrower interest/ belongs in specialized journal

Not convincing, interpretations poorly supported

Results not well interpreted, poor context

Referees can differ:

In-house editorial consultation/decision

Consultation with Editorial Board

Seek additional referee(s)

Consultation with author

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Authors can appeal:

Allowed if clear that reject decision was based on substantial referee/error, or substantial new information brought to the table

Post-publication

Letters

Technical Comments

Online comments

Recent/ongoing changes in practice at *Science*

- All co-authors notified upon manuscript submission, to check authorship.
- Detailed authorship and conflict-of-interest disclosure before acceptance by all authors.
- Senior author must answer question: "*I have personally checked all the original data that was generated by my lab or group.*"
- Restrictions on data/materials access minimized.
- No unpublished data allowed. All references/data must be available at the time of publication.

Recent/ongoing changes in practice at *Science*

- Statistical Board of Reviewing Editors
- Reproducibility
- Cross Review

EDITORIAL

Raising the bar

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ticularly when sophisticated approaches are needed. But even when taking added precautions, no review system is infallible, and no combination of reviewers can be expected to uncover all of the ways in which the interpretation of results may have gone wrong. In particular, it is difficult for reviewers to detect whether authors have approached the study with a lack of bias in their data collection and presentation.

I recall a study that I conducted years ago involving a global analysis of some oceanographic features that I was modeling to understand the rheology of oceanic plates on million-year time scales. I had only a handful of data points—perhaps a dozen or so—and the fit to

Marcia McNutt is Editor-in-Chief of Science.

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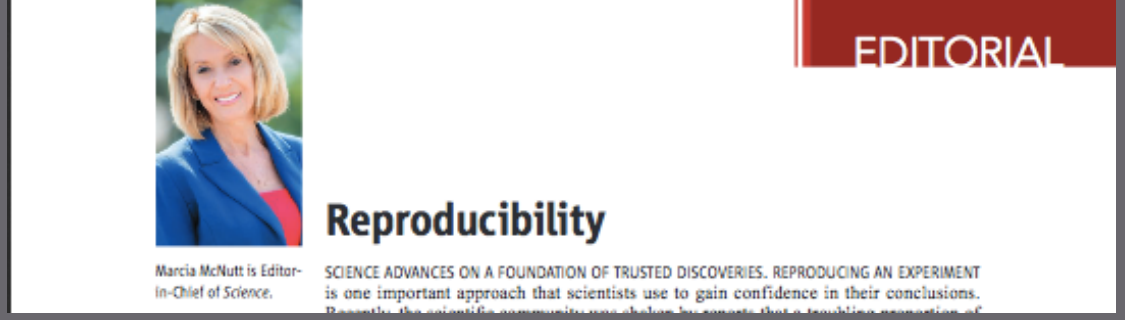
Statistical Board of Reviewing Editors

"… with much help from the American Statistical Association, Science has established, effective 1 July 2014, a Statistical Board of Reviewing Editors (SBoRE), consisting of experts in various aspects of statistics and data analysis, to provide better oversight of the interpretation of observational data."



EDITORIAL

Reproducibility

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Reproducibility

"For preclinical studies (one of the targets of recent concern), we will be adopting recommendations of the U.S. National Institute of Neurological Disorders and Stroke (NINDS) for increasing transparency. Authors will indicate whether there was a pre-experimental plan for data handling (such as how to deal with outliers), whether they conducted a sample size estimation to ensure a sufficient signal-to-noise ratio, whether samples were treated randomly, and whether the experimenter was blind to the conduct of the experiment."

Cross Review

With the goal of increasing the transparency and efficiency of the review process, *Science* initiated an experiment to look at the effect of cross-review.

1 - all first round reviews received

2 - blinded reviews made available to all reviewers

3 - 48 hours to make any additional comments.

Cross Review

Editor Evaluation

adding unnecessary time in 28% of cases
neutral in 29% of cases
helpful in 43 % of cases

unnecessary mainly when the decision was clear

helpful effect was seen mainly in an increase in confidence in the decision, rather than skewing the decision pattern

Cross Review

Reviewer Evaluation (n=164) (on a scale of 1=low through 5=high)

62% rated 4 or 5 the positive impact cross-review has on effectiveness of review process in general

63% rated 4 or 5 the positive impact cross-review has on fairness of review process

66% rated 4 or 5 the extent to which they found the other reviewer comments informative

39% said reviewer comments somewhat changed their overall judgment of manuscript and 61% said it did not change judgment at all

81% wanted cross-review to be a routine practice at *Science*

Cross Review

Lessons learned:

Provided additional support for editor decisions and gave some help in guiding the revision process

Provided some help in cases of split reviews

Was not useful in submissions with clear accept/reject decisions

Will promote transparency in *Science's* review process, which is valued by the scientific community

Could help in educating reviewers and in enhancing reviewer accountability

2013 Accepted Author Survey

How pleased were you with the overall peer-review and editing process on your recent Science paper? (n=436)

Not pleased	1.6%
	0.7%
Somewhat pleased	8.5%
	39.4%
Extremely pleased	49.8%

2013 Accepted Author Survey

To what extent did the reviewer comments improve the quality of your paper? (n=436)

No improvement	1.1%
	3.2%
Marginal improvement	19.3%
	51.1%
Significant improvement	25.2%

2013 Accepted Author Survey

Did your editor provide guidance necessary to interpret and respond to the reviewers' recommendations? (n=436)

Yes	64.4%
Somewhat	25.9%
No	9.6%

2013 Accepted Author Survey

How did Science's handling of your paper compare to other journals in which you have published in the past 2 years? (n=436)

	Very Unfavorably		About the same		Very Favorably
Speed of handling	2.8%	9.4%	23.2%	23.6%	40.1%
Thoroughness of reviews	0.9%	2.3%	25.9%	34.2%	35.6%
Quality of Editorial guidance	1.6%	1.9%	10.4%	26.6%	58.6%

Despite pitfalls of the peer review system, *Science* maintains (in common with other scientific journals) that it will remain the primary means of validating research for publication. Recognition of the potential pitfalls is the key to ensuring that the system works well, and that errors and poor scientific practices are minimized.

This marks the end of the formal presentation on *Science* policy and practice

The slides that follow do not reflect any position of *Science*, but instead were offered by Brad Wible as topics related to scientific communication that he found personally interesting and which might be useful to the PEERE group.

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• • • • •

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P-Curve: A Key to the File Drawer

Uri Simonsohn
University of Pennsylvania - The Wharton School

Leif D. Nelson
University of California, Berkeley - Haas School of Business

Joseph P. Simmons
University of Pennsylvania - The Wharton School; University of Pennsylvania - Operations & Information Management Department

April 24, 2013

Journal of Experimental Psychology: General, Forthcoming

Abstract:
Because scientists tend to report only studies (publication bias) or analyses (p-hacking) that "work", readers must ask, "Are these effects true, or do they merely reflect selective reporting?" We introduce p-curve as a way to answer this question. P-curve is the distribution of statistically significant p-values for a set of studies (ps < .05). Because only true effects are expected to generate right-skewed p-curves – containing more low (.01s) than high (.04s) significant p-values – only right-skewed p-curves are diagnostic of evidential value. By telling us whether we can rule out selective reporting as the sole explanation for a set of findings, p-curve offers a solution to the age-old inferential problems caused by file-drawers of failed studies and analyses.

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$P \neq NP$

Vinay Deolalikar
HP Research Labs, Palo Alto
vinay.deolalikar@hp.com

August 6, 2010

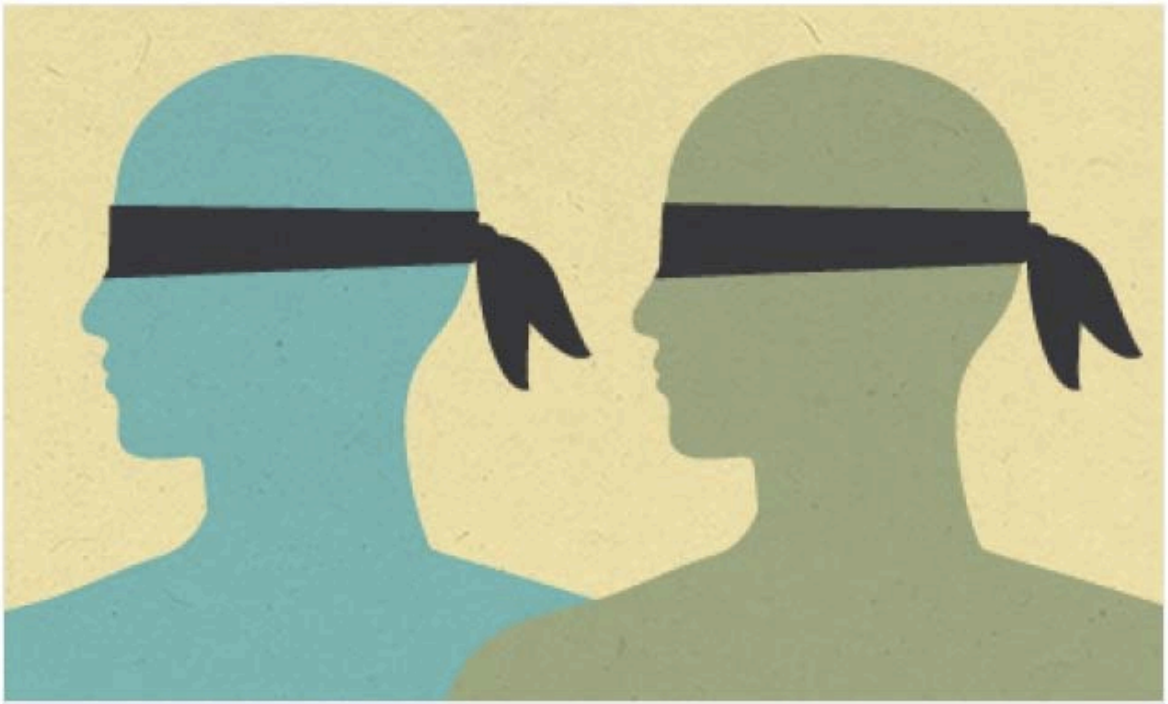
NATURE | NEWS

Journals weigh up double-blind peer review

Anonymity of authors as well as reviewers could level field for women and minorities in science.

Daniel Cressey

15 July 2014



Evaluating research papers without seeing the authors' names could reduce the effects of conscious or subconscious bias.

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The PeerJ Mission

To solve our greatest challenges we need a 21st century update to knowledge-share and scholarly communication. PeerJ's mission is to **help the world efficiently publish its knowledge**.

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PeerJ provides academics with two Open Access publication venues: *PeerJ* (a peer-reviewed academic journal) and *PeerJ PrePrints* (a 'pre-print server'). Both are focused on the Biological and Medical Sciences. Q&A + annotations provide a second route to gaining credit for knowledge-share.

***PeerJ* starts at $99** - for lifetime publishing, and public ***PeerJ PrePrints* are free** to publish. It is *always free to read, download, and reuse* PeerJ articles.

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Latest peer-reviewed articles see all

Fig 1. Juvenile green turtle severely afflicted with fibropapillomatosis (CC-BY 4.0)

FEATURED ARTICLE

Eutrophication and the dietary promotion of sea turtle tumors

SEPTEMBER 30, 2014 - Researchers investigating the tumor-forming disease fibropapillomatosis in turtles believe that the disease may be linked to the consumption of arginine-enriched macroalgae in eutrophied coastal waters - Read more

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Home

> The Episciences.org project is involved in the open access movement.

The main idea is to provide a technical platform of peer-reviewing; its purpose is to promote the emergence of epijournals, namely open access electronic journals taking their contents from preprints deposited in open archives such as arXiv or HAL, that have not been published elsewhere.

The editorial boards of such epijournals organize peer reviewing and scientific discussion of selected or submitted preprints. Epijournals can thus be considered as "overlay journals" built above the open archives; they add value to these archives by attaching a scientific caution to the validated papers.

> The project proposes an alternative to existing economic models, without competing with traditional publishers.

The objectives are to achieve free journals and implement free access to electronic versions of articles. The epijournals could be new titles or existing ones wishing to join the platform. The Episciences.org platform will host epij ournals of all scientific subjects.

Epijournals can be either new titles created from scratch, or existing ones wishing to join the platform with a compatible publishing policy.

The authors are not requested to sign restrictive agreements and retain their copyrights on their papers.

The Episciences.org platform is hosted and developed by the CCSD.

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Reproducibility Project: Psychology

Public | 49 | 32

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Do normative scientific practices and incentive structures produce a biased body of research evidence?

The Reproducibility Project: Psychology is a crowdsourced empirical effort to estimate the reproducibility of a sample of studies from scientific literature. The project is a large-scale, open collaboration currently involving more than 150 scientists from around the world.

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What Policies Increase Prosocial Behavior? An Experiment with Referees at the Journal of Public Economics

Article Citation

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Abstract

We evaluate policies to increase prosocial behavior using a field experiment with 1,500 referees at the *Journal of Public Economics*. We randomly assign referees to four groups: a control group with a six-week deadline to submit a referee report; a group with a four-week deadline; a cash incentive group rewarded with $100 for meeting the four-week deadline; and a social incentive group in which referees were told that their turnaround times would be publicly posted. We obtain four sets of results. First, shorter deadlines reduce the time referees take to submit reports substantially. Second, cash incentives significantly improve speed, especially in the week before the deadline. Cash payments do not crowd out intrinsic motivation: after the cash treatment ends, referees who received cash incentives are no slower than those in the four-week deadline group. Third, social incentives have smaller but significant effects on review times and are especially effective among tenured professors, who are less sensitive to deadlines and cash incentives. Fourth, all the treatments have little or no effect on rates of agreement to review, quality of reports, or review times at other journals. We conclude that small changes in journals' policies could substantially expedite peer review at little cost. More generally, price incentives, nudges, and social pressure are effective and complementary methods of increasing prosocial behavior.

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NIH PEER REVIEW: CHALLENGES AND AVENUES FOR REFORM

Pierre Azoulay
Joshua S. Graff Zivin
Gustavo Manso

Working Paper 18116
http://www.nber.org/papers/w18116

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Information, Bias, and Efficiency in Expert Evaluation: Evidence from the NIH *

Danielle Li
Northwestern University†

First draft: Aug 1, 2011
This draft: Sept 25, 2012

Abstract

Experts may have more information about the potential of projects in their area, but may also be biased. This paper develops a framework for separately identifying the effects of bias and information on expert evaluation and applies it in the context of peer review at the National Institutes of Health (NIH). I find that while reviewers are biased in favor of applications from their own subfield, they are also more informed about their quality. On net, the benefits of information tend to dominate, indicating that policies designed to reduce conflicts of interest may also reduce the quality of funding decisions.

PEER REVIEW IN ACADEMIC PROMOTION AND PUBLISHING: ITS MEANING, LOCUS, AND FUTURE.

PEER REVIEW IN ACADEMIC PROMOTION AND PUBLISHING: ITS MEANING, LOCUS, AND FUTURE. A Project Report and Associated Recommendations, Proceedings from a Meeting, and Background Papers. by Diane Harley and Sophia Krzys Acord. CSHE.4.11 (March 2011)

View ONLINE

Abstract:

Since 2005, and with generous support from the A.W. Mellon Foundation, The Future of Scholarly Communication Project at UC Berkeley's Center for Studies in Higher Education (CSHE) has been exploring how academic values—including those related to peer review, publishing, sharing, and collaboration—influence scholarly communication practices and engagement with new technological affordances, open access publishing, and the public good. The current phase of the project focuses on peer review in the Academy; this deeper look at peer review is a natural extension of our findings in Assessing the Future Landscape of Scholarly Communication: An Exploration of Faculty Values and Needs in Seven Disciplines (Harley et al. 2010), which stressed the need for a more nuanced academic reward system that is less dependent on citation metrics, the slavish adherence to marquee journals and university presses, and the growing tendency of institutions to outsource assessment of scholarship to such proxies as default promotion criteria. This investigation is made urgent by a host of new challenges facing institutional peer review, such as assessing interdisciplinary scholarship, hybrid disciplines, the development of new online forms of edition making and collaborative curation for community resource use, heavily computational subdisciplines, large-scale collaborations around grand challenge questions, an increase in multiple authorship, a growing flood of low-quality publications, and the call by governments, funding bodies, universities, and individuals for the open access publication of taxpayer-subsidized research, including original data sets.

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"Open" disclosure of innovations, incentives and follow-on reuse: Theory on processes of cumulative innovation and a field experiment in computational biology

Kevin J. Boudreau[a], , , Karim R. Lakhani[b],

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Highlights

- All of society's innovation systems are "open" in the sense of supporting disclosure, transfer and reuse to downstream innovators in one way or another.
- We distinguish innovation systems according to whether they implement a policy of intermediate or final disclosure.
- We theorize the choice between intermediate and final disclosure creates a tradeoff between incentives-versus-reuse and also transforms the search process (by shaping the level of independence of search and experimentation by innovators across different solution approaches).
- We demonstrate sharp first-order tradeoffs in a field experiment in which 733 expert algorithmic problem solvers competed under alternative disclosure regimes.

Abstract

Most of society's innovation systems – academic science, the patent system, open source, etc. – are "open" in the sense that they are designed to facilitate knowledge disclosure among innovators. An essential *difference* across innovation systems is whether disclosure is of intermediate progress and solutions or of completed innovations. We theorize and present experimental evidence linking intermediate versus final disclosure to an 'incentives-versus-reuse' tradeoff and to a transformation of the innovation search process. We find intermediate disclosure has the advantage of efficiently steering development towards improving existing solution approaches, but also has the effect of limiting experimentation and narrowing technological search. We discuss the comparative advantages of intermediate versus final disclosure policies in fostering innovation.