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# The manuscript reviewing process: Empirical research on review requests, review sequences, and decision rules in peer review

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## ABSTRACT

In peer review research, no study has been performed to date that has opened the “black box” of manuscript reviewing and dealt with the internal mechanisms of the process. Using as an example the peer review system of *Angewandte Chemie International Edition* (AC-IE), this study investigates which review requests are assigned by the editors to external reviewers, which sequences of review steps typically occur, and which rules are used by the editors to decide whether to accept or reject a manuscript for publication. For the investigation, information has been used on a total of 1899 manuscripts that were reviewed in the year 2000. The results show that in the majority of the manuscripts, the editors follow a so-called “clear-cut” rule: A manuscript is only accepted for publication if it has been positively assessed beforehand by two independent reviewers with regard to the importance of the results and the suitability of publication of the manuscript. For about a fifth of the manuscripts, the editors (a) consulted a top adviser for manuscript review, (b) asked a reviewer to review a manuscript revised by the author, or (c) asked a reviewer to read an appeal that an author filed against the rejection of his/her manuscript.

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## 1. Introduction

Reputable scholarly journals only publish papers that have been subjected to peer review, or critical scrutiny by scientific experts. When a manuscript is submitted, reviewers who are researching and publishing work in the same field (peers) are asked to evaluate the content of the manuscript and recommend to the editor that the manuscript be published, revised and then published, or rejected (Sense About Science, 2004). The goal of this process is to ensure that the valid article is accepted, the messy article improved, and the invalid article rejected. Peer review of contributions to the primary research literature is the principal social mechanism for quality control in academic science (Braun, 2004). Furthermore, it is the most important method by which grants and research fellowships are allocated and study programs improved (Daniel, Mittag, & Bornmann, 2007).

Studies on manuscript reviewing in recent years have generally investigated the reliability, fairness, and predictive validity of reviewers' recommendations and editors' decisions (see in the overview Daniel, 2005; Daniel et al., 2007; Weller, 2002). No study in peer review research has been performed to date examining the review process in its entirety and dealing with the various review requests that editors assign to reviewers, the typical review sequences (with different review steps), and the editors' decision rules that lead

to an acceptance or rejection of manuscripts as the outcome of the peer review process. Already in 1995, Sonnert had pointed out that “in stark contrast with the multi-faceted relevance of peer review in science, the peer review process has largely retained the characteristics of a ‘black box.’ It does produce quality judgments, but one does not quite know how they come about” (pp. 37–38). The lack of studies is justified by Gosden (2003) as follows: “As gatekeeping discourse, peer reviews remain largely under-researched principally due to their hidden status and issues of confidentiality” (p. 87).

The few studies giving insight into the black-box peer review process generally examined the connection between reviewers' ratings and editors' decisions (Bakanic, McPhail, & Simon, 1987; Fogg & Fiske, 1993; Lock, 1985; Petty & Fleming, 1999; Sternberg, Hojjat, Brigoockas, & Grigorenko, 1997; Zuckerman & Merton, 1971). Using a Latent Markov model, Bornmann, Mutz, and Daniel (2008, 2009) determined, when moving within a multistage peer review process from one evaluation stage to the next, the probability of reviewers keeping a fellowship application in the same rating category or moving it to a different one (e.g. from “award” to “possible award”). They analyzed 1954 applications for doctoral and postdoctoral fellowships from the Boehringer Ingelheim Fonds (Heidesheim, Germany), which are evaluated in three stages (first: evaluation by an external reviewer; second: internal evaluation by a staff member; third: final decision by the board of trustees). In addition, two studies could be found that examined the manuscript writing process and the authors' strategies for submitting and revising manuscripts based on reviewers' recommendations (Knorr-Cetina,

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1981; Myers, 1990). Two additional studies dealt with authors' appeals against the rejection of their manuscripts by the editor (Simon, Bakanic, & Mcphail, 1986) and the importance of manuscript revision (Bakanic et al., 1987).

In a comprehensive research project, the peer review process of the journal *Angewandte Chemie International Edition* (AC-IE) has been examined (Bornmann & Daniel, 2008a, 2008b, 2009; Bornmann, Weymuth, & Daniel, in press). AC-IE is one of the prime chemistry journals in the world, with a higher annual journal impact factor (provided by Thomson Reuters, Philadelphia, PA) than the journal impact factors of comparable journals (at 10.879 in the 2008 Journal Citation Reports, JCR, Science Edition). AC-IE is owned by the German Chemical Society (Gesellschaft Deutscher Chemiker (GDCh), Frankfurt am Main, Germany) and published by Wiley-VCH (Weinheim, Germany). It introduced peer review in 1982, primarily in conjunction with one of the types of contributions published in the journal, "communications," which are short reports on work in progress or recently concluded experimental or theoretical investigations. What the editors of AC-IE look for most of all is excellence in chemical research. Manuscripts that reviewers (and editors) deem to be of high quality are selected for publication. Manuscripts that do not meet the high standards are rejected.

This study examines the various review requests reviewers received from an editor in the AC-IE peer review process and what the typical review sequences are until the final decision for a submission. In addition, the rules by which the editors make decisions regarding acceptance and rejection of manuscripts in the peer review are investigated.

## 2. Methods

### 2.1. Manuscript reviewing at AC-IE

A manuscript submitted to AC-IE is usually subject to internal and external reviewing. First, editors at the journal evaluate whether the manuscript contributes to the development of an important area of research (internal evaluation). The editors are fulltime members of the editorial staff. If the editors find that a manuscript is an important contribution, the submission is usually sent to three independent reviewers (external evaluation) (Anon, 2008). The reviewers use an evaluation form together with a separate sheet for comments (a comment sheet). The evaluation form contains a set of six closed-ended questions with two to four response categories each. In addition to initial external reviews for a submission, additional review requests for some of the manuscripts are given to reviewers (e.g., the review of a manuscript revised by an author). At the end of a review process, a journal editor makes the decision to accept or reject a manuscript for publication on the basis of the requested reviews and on their own evaluations. The author is usually given an acceptance if two positive reviews are returned to the editorial office.

### 2.2. Database for the present study

This investigation examined information from a total of 1899 manuscripts that were submitted by the authors in order to be published as a communication and that were reviewed in the year 2000. The somewhat older manuscript cohort was selected as the database, since for an examination of the predictive validity of the editorial decisions (see the results of this examination in Bornmann & Daniel, 2008a, 2008b), there should be a time interval of several years between reviewing a manuscript and measuring the indicator for scientific quality—in this case, citations. The information on the manuscripts was taken from archived material that was stored electronically by the publisher, Wiley-VCH. Of the 1899 manuscripts, 46% ( $n=878$ ) were accepted for publication in AC-IE and 54% ( $n=1021$ ) were rejected. The editorial decision to accept or reject a

manuscript was made for 1896 manuscripts based on an external review. The editors rejected three manuscripts without any external review (see Göllitz, 2005).

Of the 1021 manuscripts submitted to AC-IE but not published in the end, 11 were withdrawn by the author during the review process. A withdrawal may be initiated by the author him- or herself; the categorization of a manuscripts as "withdrawn by the author," however, may also be initiated by an editor. For example, in a letter from an editor to an author, the editor writes, "Thank you for your e-mail of May 5 in which you wrote that you were about to send the revised versions of the above-mentioned communications. Since again more than one month has passed and we still have not received the manuscripts I now assume that you are no longer interested in publishing your results in AnCh and consider both manuscripts as withdrawn."

## 3. Results

### 3.1. Review requests which reviewers in the AC-IE peer review received from the editors

Table 1 shows the various review requests that reviewers in the AC-IE peer review received from the editors. A total of 4861 reviews were prepared by the reviewers on an evaluation form as well as on a comment sheet ( $n=3700$ ), only on a comment sheet ( $n=1037$ ) or only on an evaluation form ( $n=58$ ). The 4861 reviews relate to 1896 manuscripts; thus on average, a manuscript received 2.6 reviews of various types before an editor made a publication decision. Of the 4861 reviews, 4795 (99%) were assigned to a particular review request in Table 1; 66 reviews (1%) could not be classified, because documents were not available in the AC-IE archive material.

#### 3.1.1. Initial external review of a submission

As Table 1 shows, 4219 reviews are initial external reviews of a submitted manuscript, which was to be published in AC-IE as a communication; in five cases, the reviewer had already reviewed the manuscript for another journal and sent this review to the editor of AC-IE. According to this, 87% of the reviews in the table ( $n=4224$ ) are initial external reviews. According to Göllitz (2005), in the case of AC-IE, it is common for publication decisions on submissions to be made when the requested initial external reviews are available to the editor: "After reading the manuscript and the reports (or the only report in some cases) the editors in most cases are quite capable of deciding on the fate of a manuscript" (p. 5540). Correspondingly, it is shown that the AC-IE editors decided on 79% ( $n=1471$ ) of those 1858 manuscripts, which were reviewed externally and have no missing documents in the review process, using these reviews alone.

#### 3.1.2. Review by a top adviser

For a total of 108 manuscripts, an editor requested the review from a so-called "top adviser." As Table 1 shows, a total of 111 reviews were prepared by a top adviser. An additional six reviews relate to a manuscript revised by the authors on the recommendation of a top adviser. Top advisers are primarily consulted by the editors for a manuscript when the ratings of the reviewers who initially reviewed a submission greatly differ and do not allow any final publication decision on the manuscript to be made. In a letter from an editor to an author, this review step was described as follows: "Since their recommendations [the recommendations of two reviewers] were drastically different, we have asked, as in other cases like this, a top adviser for his advice. His answer was decisive in this matter."

#### 3.1.3. Review of a revised manuscript

Manuscripts are provisionally accepted by the AC-IE for publication if an editor feels a revision of the manuscript is necessary, based on the initial external review, before a final decision can be made. The final decision on a manuscript revised by the authors is in many cases

**Table 1**  
Evaluation form and comment sheet for various review requests which a reviewer received from an AC-IE editor (in absolute frequencies).

Review request	Evaluation form and comment sheet	Only evaluation form	Only comment sheet	Total	Total (row percent)
<i>Initial review of a submission</i>					
Initial review	3671	56	492	4219	
Initial review for another journal already available	0	0	5	5	
<b>Total</b>				<b>4224</b>	<b>86.9</b>
<i>Top adviser</i>					
Review of a submission and the initial review prepared for it	10	0	101	111	
Review of a revision recommended by a top adviser	1	0	5	6	
<b>Total</b>				<b>117</b>	<b>2.4</b>
<i>Manuscript revised by the author</i>					
Review of a revised manuscript	9	1	293	303	
Review of a manuscript that was revised twice	0	1	10	11	
Review of a manuscript that was revised three times	0	0	1	1	
<b>Total</b>				<b>315</b>	<b>6.5</b>
<i>Author files an appeal against the rejection of a manuscript</i>					
Review of an appeal by a reviewer who had previously reviewed the submitted manuscript	3	0	82	85	
Review of an appeal by a reviewer who had not reviewed the submitted manuscript	6	0	48	54	
<b>Total</b>				<b>139</b>	<b>2.9</b>
<i>The review is missing in the archive material</i>					
<b>Total</b>	<b>3700</b>	<b>58</b>	<b>1037</b>	<b>4861</b>	<b>100</b>

made by an editor without a further external review step. In a number of cases, however, an additional review is requested from at least one of the reviewers who had originally reviewed the manuscript. As Table 1 shows, there are 303 reviews of a revised manuscript and 12 reviews of a manuscript that has been revised twice or even three times. A total of 215 manuscripts were revised by the authors and then resubmitted for external review. In many cases – as these figures show – not one but several reviewers were asked to review a revised manuscript, and to some extent they did not review only one version but rather several versions of a manuscript.

### 3.1.4. Review of an author's appeal against the rejection of a manuscript

For 123 manuscripts, authors filed an appeal against the rejection of their manuscript by an editor. As one editor wrote to an author: "In principle every author of a rejected paper at ANGEWANDTE CHEMIE has the right to appeal! For this it is necessary to submit a revised (or the original) manuscript and to present a rebuttal to the referees' arguments. It certainly helps when an author sees major factual errors in the referees' statements." Of the 123 manuscripts for which authors filed an appeal, 33% ( $n=41$ ) were accepted for publication in the end; 67% of the manuscripts ( $n=82$ ) remained rejected. There are comparative figures here for the journals *American Sociological Review* and *The Lancet* (see also Weller, 2002): "Thirteen percent of the authors who complained succeeded in having the decision reversed and their manuscripts accepted for publication [in the *American Sociological Review*]" (Simon et al., 1986, p. 259). Ten percent and 13% of the successful appeals are reported by Spersneider, Kleinert, and Horton (2003) for *The Lancet* in 2001 and 2002.

An external reviewer is not involved in every case at AC-IE to make a decision on an author's appeal. "Editors can make mistakes, and in the eyes of authors, almost every rejection is a mistake. However, a rebuttal should only follow, if the decisive referee comments are inaccurate or wrong. When it is 'only' a difference of opinion on the importance of an article then a rebuttal is usually rejected immediately" (Gölit, 2005, p. 5540). In many cases, the editorial office receives a late initial external review (i.e., from a reviewer who had been asked for a review but sent it to the editorial office too late to be used) that can be used to make a decision about the appeal. An editor writes to an author, "We received a late referee report which is also

negative (see enclosure). Therefore we cannot change our decision. I am sorry but I cannot answer more positively."

In most cases (in 93 of 123 manuscripts) of an author's appeals, an additional review step is introduced so that the editor can decide on the appeal. An editor writes to an author, "The rebuttal and the revised version (if appropriate) are ... sent to the referee(s) whose recommendation(s) caused the rejection. In addition, the whole case is presented to a court-of-appeal referee. When all statements are available, the editor makes the final decision." The editors' decisions on appeals in the case of 93 manuscripts, as Table 1 shows, were made using 85 reviews that were written each by a reviewer who had already reviewed the manuscript initially, as well as using 54 reviews from a reviewer (generally a court-of-appeal reviewer) who had not yet reviewed the manuscript.

### 3.2. Review sequences in AC-IE peer review

After looking at the various review requests in Section 3.1. that reviewers received in the AC-IE peer review process, the typical review sequences that lead to acceptance or rejection of a manuscript by an editor are examined. As Table 2 shows, in the 1896 manuscripts subjected to external review there were up to seven review steps before a decision was made. For 51% of the manuscripts, there were two and for 30% three steps; for 13% of the manuscripts, there were four or more steps (for 6% only one step). As shown in the breakdown

**Table 2**

Acceptance and rejection of manuscripts broken down according to the number of review steps in the peer review process (in percent).

No. of steps	$n$	Row percent	Acceptance ( $n=878$ )	Rejection ( $n=1018$ )	Total
1	122	6.4	36.9	63.1	100.0
2	962	50.7	40.6	59.4	100.0
3	570	30.1	50.2	49.8	100.0
4	138	7.3	<b>+65.9</b>	<b>34.1</b>	100.0
5, 6 or 7	104	5.5	<b>+62.5</b>	<b>37.5</b>	100.0
<b>Total</b>	<b>1896</b>	<b>100.0</b>	<b>46.3</b>	<b>53.7</b>	<b>100.0</b>

Notes. For 3 of the total of 1899 manuscripts, there was no external review, and the editor rejected the manuscript without review.  
 $\chi^2$  (4,  $n=1896$ ) = 5.25,  $p < 0.05$ , Cramer's  $V = 0.17$ . Cells with standardized residuals greater than 2 (or smaller than -2) are shown in the table in boldface.

of the number of review steps according to accepted and rejected manuscripts, review sequences with many steps are disproportionately frequently related to acceptance. While approximately two thirds of the manuscripts with more than three steps were accepted, about one third were rejected. As is shown below, this can primarily be attributed to the fact that review steps, after the initial reviewing of a submission, frequently relate to a manuscript revised by the author that in most cases is accepted for publication.

Several review steps are possible for each submission (these are in italics in Table 1): (a) initial review of a submitted manuscript (SM), (b) review by a top adviser (TA), (c) review of a revised manuscript (RE), (d) review of an appeal (AP), as well as (e) review data is missing (DM). For the 1899 manuscripts, there are a total of 55 different review sequences. The 15 sequences that occur more frequently than nine times are shown in Table 3 (they account for 95% ( $n = 1805$ ) of the manuscripts). For each sequence, the proportion of accepted and rejected manuscripts is shown in the table.

As Table 3 shows, an editor decided on about half of the manuscripts using two initial external reviews. Submitted manuscripts generally go out to three reviewers. The decision on a manuscript is generally made when the editor has two of the three requested reviews (in the data set of this study for 949 manuscripts, see Table 3). An editor explains this process in a letter to an author as follows: “Many papers are sent initially to three referees (as in this case), but in today’s increasingly busy climate there are many referees unable to review papers because of other commitments. On the other hand we have a responsibility to authors to make a rapid, fair decision on the outcome of papers.” The editorial decision to use two reviewer reports is standard practice at journals other than AC-IE. For example, the editors of the journal *Academic Psychiatry* write: “Ordinarily we will not render a decision unless we have received a minimum of two reviews for a given manuscript. This policy ensures that authors are given a substantial amount of specific feedback from which to draw in drafting a revision. Often reviews are mixed (i.e., a single reviewer will have an ambiguous response to a paper) or in conflict (i.e., different reviewers express different degrees of enthusiasm – or not – for a paper)” (Roberts, Coverdale, Edenharder, & Louie, 2004, p. 82).

If at AC-IE all three reviewers answered promptly or the editor felt it was necessary to wait for an additional initial external review for his/her final decision after two reviews have already been received,

the editor made a decision on a manuscript using three reviews. In the data set of this study this occurred for 385 manuscripts, about one fifth of total (see Table 3). As Table 3 shows, a publication decision was made for 119 manuscripts using only one review. This step is justified as follows in a letter in which an editor justifies the rejection of a manuscript to an author: “I am very sorry that I cannot give a more positive reply in a case such as this one. We have been receiving so many communications lately that we can almost only accept those manuscripts which receive two clear-cut positive referee reports. The second referee returned the manuscript without a report.”

As Table 3 shows, in addition to two initial external reviews, a top adviser was consulted for the decision to accept or reject a submission for a total of 69 manuscripts. In the case of 28 manuscripts, authors appealed and their manuscript had two external reviews. In the case of 176 manuscripts, after two or three initial reviews for a submission, a manuscript revised by the authors based on review comments was reviewed. The results of the residual analysis in Table 3 indicate that the probability of acceptance of a revised manuscript after external review is disproportionately high: Over 80% of manuscripts with a review sequence that includes at least one review of a revised manuscript were accepted for publication and less than 20% of these manuscripts were rejected (see also here the results of Bakanic et al., 1987). Neither the review by a top adviser in a review sequence for a manuscript nor the review of an author’s appeals leads to a similar disproportionately high or low frequency of acceptance or rejection in the AC-IE peer review process (see Table 3).

### 3.3. Editors' decision rules in AC-IE peer review

The analysis of the review sequences in Table 3 showed that more than about four fifths of the manuscripts reviewed at AC-IE in 2000 received a publication decision with the help of one to three initial reviews. Using the ratings with which the reviewers evaluated a manuscript in these cases, the authors of this article examined the decision rules an editor at AC-IE follows when accepting or rejecting a manuscript for publication.

#### 3.3.1. Decision rule for two reviews

The letters editors write to notify authors of a manuscript’s rejection generally include wording such as “we have been receiving so many manuscripts that we have almost only been accepting those with two clear-cut referee reports,” or “we have to reject almost all manuscripts that do not receive two clear-cut recommendations.” However, the letters do not provide a clear explanation of what the editors mean by “clear-cut;” there are only hints, such as the indication found in the following excerpt of a letter from an editor to an author: “Regrettably we can currently only accept those papers that have two clear-cut positive recommendations from referees, and in rare cases we even have to decide against these authors (our rejection rate has risen to about 60%). Even though referee [X] deems your results important and certainly worth publishing, he does not recommend publication in *Angewandte Chemie*. Therefore, your paper was not rejected solely on the grounds of referee [Y] [who rated the results as unimportant and recommended rejection of the manuscript].” In the comment on reviewer X, the editor is referring to the two key questions on the evaluation form: “How important do you consider the results?” and “Do you recommend acceptance of the Communication?”

From these and similar indications in the editors’ letters, it seems that in general a manuscript is published in AC-IE only if two reviewers rate the results of the study as important or very important and also recommend publication in the journal. Thus, the clear-cut rule seems to be that a manuscript is published only if two reviewers choose the response “very important” or “important” to the question “How important do you consider the results?” and also do not answer “no” to the question “Do you recommend acceptance of the

**Table 3**  
Acceptance and rejection of a manuscript by the editor, broken down according to the various review sequences (line percents, arranged decreasing according to the number of how frequently a sequence occurs in the data set).

Review sequence	Acceptance (n=829)	Rejection (n=976)	n
SM   SM   OO   OO   OO   OO   OO	<b>40.5</b>	<b>59.5</b>	949
SM   SM   SM   OO   OO   OO   OO	48.1	51.9	385
SM   OO   OO   OO   OO   OO   OO	37.0	63.0	119
SM   SM   TA   OO   OO   OO   OO	33.3	66.7	69
SM   SM   RE   OO   OO   OO   OO	<b>91.2</b>	<b>8.8</b>	68
SM   SM   SM   RE   OO   OO   OO	<b>86.5</b>	<b>13.5</b>	52
SM   SM   SM   RE   RE   OO   OO	<b>88.9</b>	<b>11.1</b>	36
SM   SM   AP   OO   OO   OO   OO	32.1	67.9	28
SM   SM   RE   RE   OO   OO   OO	<b>85.0</b>	<b>15.0</b>	20
SM   SM   SM   SM   OO   OO   OO	38.9	61.1	18
SM   SM   SM   AP   OO   OO   OO	37.5	62.5	16
SM   SM   SM   AP   AP   OO   OO	35.7	64.3	14
SM   SM   SM   TA   OO   OO   OO	36.4	63.6	11
DM   DM   DM   OO   OO   OO   OO	20.0	80.0	10
SM   SM   AP   AP   OO   OO   OO	40.0	60.0	10
Total	45.9	54.1	1805

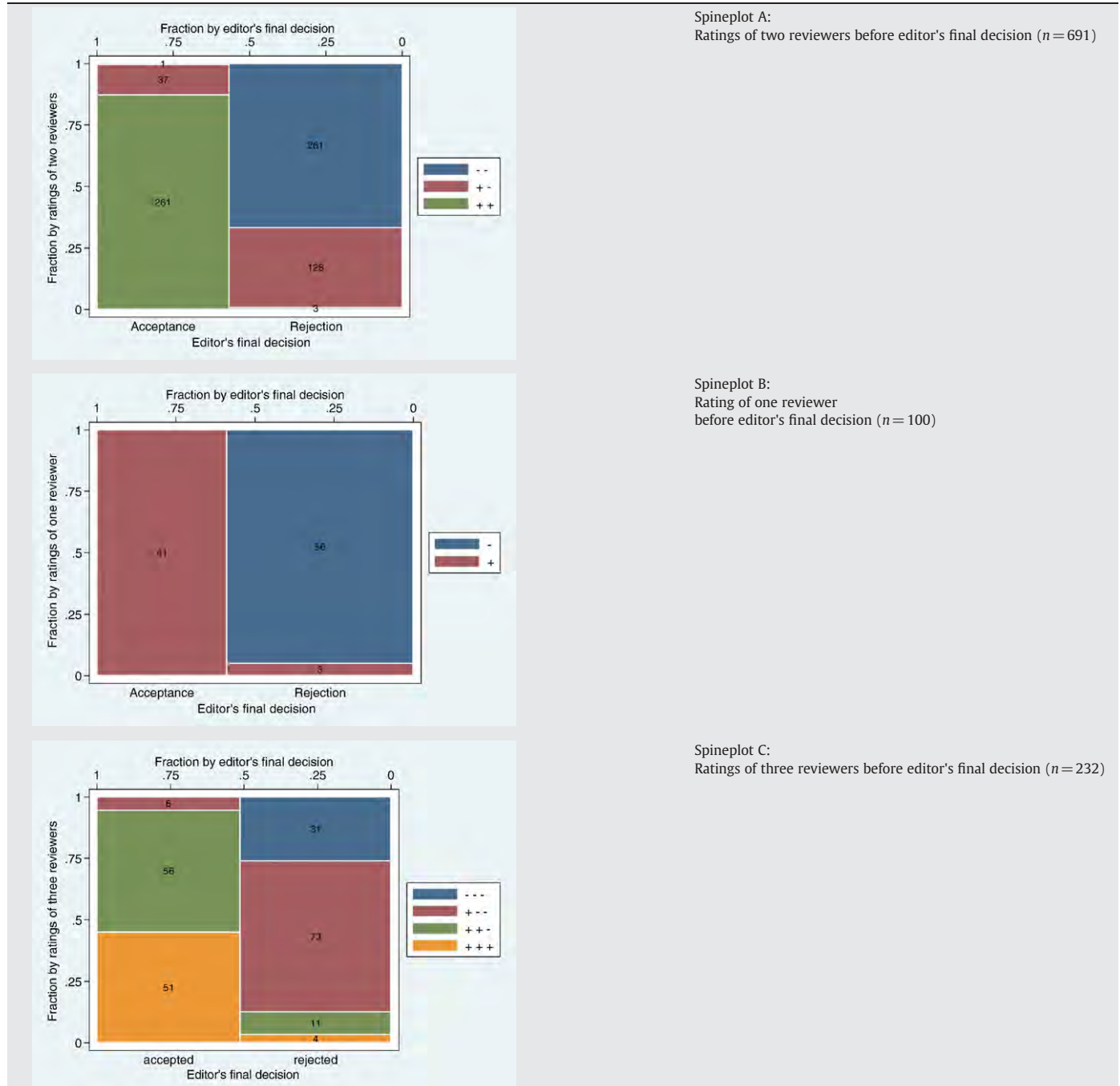
Notes. Abbreviations: SM: Initial review of a submitted manuscript; TA: review by a top adviser; RE: review of a revised manuscript; AP: review of an appeal; DM: review data is missing.  
 $\chi^2$  (14,  $n = 1805$ ) = 156.8,  $p < 0.05$ , Cramer’s  $V = 0.30$ . Cells with standardized residuals greater than 2 (or smaller than -2) are shown in boldface in the table.

communication?" The editors appear to deviate from this rule in only a few cases (see quotation above).

As Table 3 shows, there are two reviews for each of 949 of the total of 1899 manuscripts (i.e., for 50% of the manuscripts), which editors used to make their decision on a manuscript. For 691 of the 949 manuscripts, both reviewers answered both of the above-mentioned

questions on the evaluation form (see Table 3, first line). The reduction in the number of cases is primarily due to the fact that, in many cases, the reviewers did not completely fill out the evaluation form or only filled out the comment sheet and not the evaluation form with the closed-ended questions (see here the results in Section 3.1.). In Table 4 (upper diagram) a spineplot (Cox, 2008) shows the

**Table 4**  
Spineplots of the acceptance or rejection of a manuscript by the editor, broken down according to the ratings of two, one, or three reviewers before an editor's final decision.



Notes. A "+" means that a reviewer answered the question "How important do you consider the results?" (Possible answers: "very important," "important," "less important," "unimportant") with "very important" or "important," and did not answer the question "Do you recommend acceptance of the communication?" (Possible answers: "Yes, without alterations," "Yes, after minor alterations," "Yes, but only after major alterations," "No") with "No." A "-" means that a reviewer answered the question "How important do you consider the results?" with "less important" or "unimportant," and/or the question "Do you recommend acceptance of the communication?" with "No". Example of how to read the diagrams: In the spineplots, the final decision is shown on the x axis and the reviewers' rating is shown on the y axis. The colored areas respectively indicate the fraction of a certain category (either a category of the final decision or a category of the reviewer's ratings). The figures within the various colored areas are the number of manuscripts in a category. Spineplot A, for example, indicates that somewhat more than half of the manuscripts were rejected. As both red colored areas show, the proportion of manuscripts with a positive rating of the one and a negative rating of the other reviewer is significantly greater under the rejected manuscripts than under the accepted manuscripts.

relationship between the answers from two reviewers that were taken into account in the editor's decision, and the editor's final decision (acceptance or rejection). A "+" in the diagram means that a reviewer answered the question "How important do you consider the results?" with "very important" or "important," and did not answer the question "Do you recommend acceptance of the communication?" with "no." A "-" means that a reviewer answered the question "How important do you consider the results?" with "less important" or "unimportant," and/or the question "Do you recommend acceptance of the communication?" with "no." As an initial important finding, it is shown in the frequency distributions in the diagram that the editors only publish those manuscripts in AC-IE that, according to the above-mentioned clear-cut rule, received positive reviews from two reviewers. A total of 261 manuscripts were positively assessed by the first and second reviewer and were accepted for publication; 389 manuscripts were negatively assessed by the first and/or second reviewer and were rejected by the editor (261 manuscripts with "--" and 128 manuscripts with "+ -").

In Table 4 (spineplot A), only 41 cases are shown for which the clear-cut rule was not followed for an editor's decision. The deviations (only 6% of the manuscripts, for which those with two reviews were decided upon) show that not all decisions at AC-IE are "based just on the simple mathematics of addition ... Not all referee reports are equally good" (Gölit, 2005, p. 5540). According to Campanario and Acedo (2007) editors have an important part to play in moderating the conclusions of reviewers. Some reviewers "do a thorough job, some are hyper critical, and some give the paper to a graduate student so the opinions are not really from the expert" (Godlee, 2000). Furthermore, reviewers may judge through the filter of a "personal 'reading lens'" (Bedeian, 2004, p. 201; see also Clark & Wright, 2007). Correspondingly, an AC-IE editor writes in a letter in which he notifies an author of the rejection of the manuscript: "My decision is based on my knowledge of the background of all referees (and certainly on my reading of the manuscript)."

The deviations of the editors from the clear-cut rule in 41 of the manuscripts are further explained by information from the archive material: Three manuscripts were rejected, although both reviewers had previously positively assessed them (see Table 4, upper diagram). As the archive material shows in these cases, one manuscript was withdrawn by the author during the review process (see Section 2) and in the case of two manuscripts, the editor suggested to the author another journal (from Wiley-VCH) than AC-IE. Thirty-eight manuscripts received only one positive ( $n=37$ ) or no positive ( $n=1$ ) review from the first or second reviewer, but were nevertheless published in AC-IE (see Table 4, spineplot A). Closer inspection of the archive material in these cases suggests the following five reasons for deviation from the clear-cut rule: (a) the reviewer from whom the negative rating originates qualified the rating with a positive comment; (b) the reviewer's critique with the negative rating primarily related to a journal (of Wiley-VCH) other than AC-IE as a preferable place of publication; (c) the reviewer suggested that publication in the form of a full paper was more suitable than publication in the form of a communication; (d) the reviewer from whom the positive rating originates assessed the manuscript extremely positively (i.e., the manuscript was recommended for publication without alterations or after minor alterations, or the reviewer regarded the results as very important); and/or (e) the opinion of the reviewers from whom the negative rating originates leaned in a positive direction (i.e., the results of the study were characterized by the reviewer as "unimportant" or "less important," however, he/she recommended publication in AC-IE after minor alterations).

### 3.3.2. Decision rule for one review

As it was already shown above, the editors made decisions on 119 manuscripts using only one review (see Table 3). For 100 of the 119

manuscripts, the reviewer answered both above-mentioned questions on the evaluation form. As the results show in Table 4 (spineplot B), as expected, those manuscripts with a positive review were accepted for publication and those with a negative review were rejected by AC-IE.

Only three manuscripts (i.e., 3% of all cases with one review prior to the editorial decision) were rejected by the editor, although the reviewer had previously positively assessed the manuscript. As the archive material in these cases shows, the editor recommended to the author a journal other than AC-IE as the place of publication for one manuscript. An additional manuscript was rejected because it was conceptually similar to a manuscript already accepted for publication. In a letter from an editor to an author, notifying the author of rejection, the editor writes, "Some time ago we accepted a paper on ... which is in print now. Since it is our policy to reject conceptually closely related papers at this stage, we are unfortunately unable to accept your manuscript for publication." The third manuscript was not accepted for publication by AC-IE because the findings of the study were not yet sufficient for publication, in an editor's opinion: "We agree with the comments made by the referee that although your findings are novel they do not represent a sufficient basis for publication of a communication at the present time. If, on the other hand, you have in the meantime obtained new results that are pertinent to the referee's comments, there would, in principle, be no obstacle to publishing an appropriately supplemented manuscript."

### 3.3.3. Decision rule for three reviews

Table 4 (spineplot C) shows the connection between an editor's decision (acceptance or rejection) and the ratings (positive ("+") or negative ("-")) of three reviewers. As Table 3 shows, the editors consulted three reviewers for their decision in the case of 385 manuscripts. For 232 of the 385 manuscripts, all three reviewers answered both above-mentioned questions on the evaluation form. As the results show in Table 4 (spineplot C), as expected, on the basis of the clear-cut rule (for two reviews prior to the editorial decision, see above), those manuscripts accepted for publication in this case received a positive review from at least two reviewers. That means that a negative review with otherwise positive reviews generally leads to the acceptance of the manuscript; a positive review with otherwise negative reviews is correspondingly linked to the rejection of the manuscript. An editor of the *Journal of Management Studies* also reported on a similar procedure in the case of three reviews: "*Journal of Management Studies*, like most leading management journals, uses at least three reviewers. In these circumstances, it is frequently the case that at least two reviewers agree on the key issues and make identical overall recommendations" (Clark & Wright, 2007, p. 618).

As the results in Table 4 (spineplot C) show, the editors deviated from this rule in a total of 21 manuscripts (i.e., for only 9% of cases with three reviewers' ratings before the final decision). Four manuscripts were not published in AC-IE, although they received three positive ratings from the reviewers. The archive material for all four cases shows that the manuscripts were withdrawn by the authors during the review process. Also, of the 11 manuscripts that were rejected with two positive reviews and one negative review by an editor, two were withdrawn by the authors. In the case of the other rejected manuscripts (with "+ + -") a journal (of Wiley-VCH) other than AC-IE was seen as being more suitable and/or the comments of a reviewer who gave the manuscript a positive rating were however critically. As the following excerpt from a letter from an editor to an author shows, it also happens that significantly greater relevance is given to the negative review than to the two positive reviews: "I weighted the most negative report strongest knowing the specific expertise of all three referees."

As the spineplot C in Table 4 shows for the manuscripts accepted for publication, there are six manuscripts that received two negative ratings and one positive rating. Closer inspection of the archive

material suggests that in these cases, the reasons for deviation from the general rule which were listed above in connection with the deviation from the two clear-cut rule can explain the acceptance of the manuscripts (e.g., at least one reviewer from whom a negative rating originates, qualified this rating with a positive comment, or the review of at least one reviewer from whom a negative rating originates leads, however, in a positive direction).

#### 4. Discussion

This study presents an inside view of the workings of a large scholarly journal. The results give a sense of commitment to careful work, which is probably typical of most prestigious journals. There are no studies published up to now with this inside examination of the step-by-step process of manuscript reviewing. The underlying data can only come from editorial offices willing to take a close look at their process.

If the AC-IE editors decide on a manuscript using only initial external reviews, they generally follow a so-called clear-cut rule: Only those manuscripts are accepted for publication that were positively assessed by the reviewers (in most cases, two) with regard to the importance of the results and the suitability of publication of the manuscript. According to Wager, Parkin, and Tamber (2006), AC-IE is a journal that relies on reviewer judgments to a great extent (e.g., always accepting submissions if two or a majority of reviewers recommends this). In many other journals, “although editors base their decision on the reviewers' comments, they do not necessarily follow the reviewers' recommendations about acceptance or rejection” (Wager et al., 2006). The use of a clear-cut rule in AC-IE peer review can lend not only necessary legitimization by experts in the chemical community to the editors' publication decisions, but it also certainly represents a very effective internal mechanism to decide on the large amount of manuscripts received day after day by the editorial office (see here Gölitz, 2003, 2004).

Through use of the clear-cut rule by AC-IE editors, it can be critically observed that for one submission, in general, three reviewers are contacted, although for the clear-cut rule (in general) only two reviewer reports are necessary. By this editorial procedure, the review process can indeed be expedited. However, since the rejection rate at AC-IE has been significantly higher for some years than the acceptance rate, a single negative review would suffice for the majority of the manuscripts in accordance with the clear-cut rule in order for the editorial decision (a rejection) to be made. According to this rule, a second review would thus only need to be requested for a submission if either publication is recommended in the first review or the first review did not form a sufficient basis to reject a submission. According to Hargens (1990) physics journals in most cases employ a “single initial reviewer” system in place of the usual “two initial reviewer” system (see here also Starbuck, 2005).

The value of a peer review process is generally measured by the extent to which the “best” manuscripts from the pool of submissions are actually accepted for publication. As a post-publication evaluation of the AC-IE editorial decisions using bibliometric analyses demonstrated (Bornmann & Daniel, 2008a, 2008b), the peer review system can be characterized as very successful in selecting the best manuscripts from amongst the multitude of submissions (similar results had already been provided by Daniel, 1993). The results of negative binomial regression models show that being accepted by AC-IE increases the expected number of citations by up to 50% against being rejected and published elsewhere. A comparison of average citation counts of accepted and rejected – but published elsewhere – manuscripts with international scientific reference standards reveal that mean citation counts below baseline values were significantly less frequent for accepted than for rejected manuscripts (see here also Bornmann et al., 2009). All in all, the results of this study confirm that

peer review at AC-IE selects the best scientific work with the highest impact of chemical research.

For peer review systems that rely on reviewer judgments to a great extent (such as that of AC-IE), it is frequently critically observed that “reviewers' advice about whether to accept a manuscript is ... limited because they cannot know about all of the factors that go into the decision to accept or reject a manuscript ... Reviewers are valuable consultants, providing second opinions and a rich array of insights. But they are not ‘referees’ – that is, they should not, on their own, decide how the game is played” (Fletcher & Fletcher, 2003, p. 67). The editorial decision should be informed, but not determined, by the content of the reviewers' reports (Rowbottom, 2008). Given this critique of manuscript reviewing, public peer review systems have been suggested in recent years, in which designated reviewers and other interested members of the scientific community can review a manuscript, and authors can respond to critiques at an earlier stage.

For example, the journal *Atmospheric Chemistry and Physics* (ACP, JF 2008 = 4.927) has a two-stage publication process and interactive discussion (Koop & Pöschl, 2006; Pöschl, 2004). In the first stage, manuscripts that pass a rapid prescreening process (access review) are immediately published as “discussion papers” on the journal's Web site. They are then made available for interactive public discussion, during which the comments of designated reviewers, additional comments by other interested members of the scientific community, and the authors' replies are published alongside the discussion paper. In the second stage, manuscript revision and peer review are completed in the same way as in journals like AC-IE. The extent to which the “new” peer review process of the ACP has advantages over the closed peer review system of AC-IE to select the “best” scientific work with the highest impact (with regard to efficiency and quality of the publication decisions) will be examined in an ongoing research project.

#### 5. Conclusion

Countless decisions in journal publishing are based on peer review. As collection managers, providers of resources and services to researchers, and scholars, members of the library and information science community are deeply engaged with refereed journals, that is, journals that have passed through the peer review process. What constitutes a refereed journal, however, varies from journal to journal. The peer review process itself is more or less a black box. This study is one of the few attempts to open the black box of peer review and to investigate the validity of editorial decisions based on peer review. Although the data used refer to a chemistry journal, the results are applicable to all other journals, which work with the traditional system of closed peer review – independent of the discipline. The acceptance of a hoax article by the *Open Information Science Journal* in June 2009 after the publisher said it had been peer-reviewed (Gilbert, 2009) shows that much more research on the black box of peer review is needed.

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## References

- Anon. (2008). Is peer review honest? *C&EN Peer Review*, 86(6), 48–49.
- Bakanic, V., McPhail, C., & Simon, R. J. (1987). The manuscript review and decision-making process. *American Sociological Review*, 52(5), 631–642.
- Bedeian, A. G. (2004). Peer review and the social construction of knowledge in the management discipline. *Academy of Management Learning and Education*, 3(2), 198–216.
- Bornmann, L., & Daniel, H. -D. (2008). The effectiveness of the peer review process: Inter-referee agreement and predictive validity of manuscript refereeing at *Angewandte Chemie International Edition*, or rejected but published elsewhere. *Angewandte Chemie International Edition*, 47(38), 7173–7178.
- Bornmann, L., & Daniel, H. -D. (2008). Selecting manuscripts for a high impact journal through peer review: A citation analysis of communications that were accepted by *Angewandte Chemie International Edition*, or rejected but published elsewhere. *Journal of the American Society for Information Science and Technology*, 59(11), 1841–1852.
- Bornmann, L., & Daniel, H. -D. (2009). The luck of the referee draw: The effect of exchanging reviews. *Learned Publishing*, 22(2), 117–125.
- Bornmann, L., Marx, W., Schier, H., Rahm, E., Thor, A., & Daniel, H. D. (2009). Convergent validity of bibliometric Google Scholar data in the field of chemistry: Citation counts for papers that were accepted by *Angewandte Chemie International Edition* or rejected but published elsewhere, using Google Scholar, Science Citation Index, Scopus, and Chemical Abstracts. *Journal of Informetrics*, 3(1), 27–35.
- Bornmann, L., Mutz, R., & Daniel, H. -D. (2008). Latent Markov modeling applied to grant peer review. *Journal of Informetrics*, 2(3), 217–228.
- Bornmann, L., Mutz, R., & Daniel, H.-D. (2009). The influence of the applicants' gender on the modeling of a peer review process by using latent Markov models. *Scientometrics*, 81(2), 407–411.
- Bornmann, L., Weymuth, C., & Daniel, H.-D. (in press). A content analysis of referees' comments: How do comments on manuscripts rejected by a high-impact journal and later published in either a low- or high-impact journal differ? *Scientometrics*, doi:10.1007/s11192-009-0011-4.
- Braun, T. (2004). Keeping the gates of science journals: Gatekeeping indicators of national performance in the sciences. In H. F. Moed, W. Glänzel, & U. Schmoch (Eds.), *Handbook of quantitative science and technology research. The use of publication and patent statistics in studies of S&T systems* (pp. 95–114). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Campanario, J. M., & Acedo, E. (2007). Rejecting highly cited papers: The views of scientists who encounter resistance to their discoveries from other scientists. *Journal of the American Society for Information Science and Technology*, 58(5), 734–743.
- Clark, T., & Wright, M. (2007). Reviewing journal rankings and revisiting peer reviews: Editorial perspectives. *Journal of Management Studies*, 44(4), 612–621.
- Cox, N. J. (2008). Speaking Stata: Spineplots and their kin. *Stata Journal*, 8(1), 105–121.
- Daniel, H. -D. (1993). *Guardians of science: Fairness and reliability of peer review*. Weinheim, Germany: Wiley-VCH.
- Daniel, H. -D. (2005). Publications as a measure of scientific advancement and of scientists' productivity. *Learned Publishing*, 18, 143–148.
- Daniel, H. -D., Mittag, S., & Bornmann, L. (2007). The potential and problems of peer evaluation in higher education and research. In A. Cavalli (Ed.), *Quality Assessment for Higher Education in Europe* (pp. 71–82). London: Portland Press.
- Fletcher, R. H., & Fletcher, S. W. (2003). The effectiveness of journal peer review. In F. Godlee, & T. Jefferson (Eds.), *Peer review in health sciences* (pp. 62–75), 2. ed., London: BMJ Books.
- Fogg, L., & Fiske, D. W. (1993). Foretelling the judgments of reviewers and editors. *American Psychologist*, 48(3), 293–294.
- Gilbert, N. (2009). Editor will quit over hoax paper. Retrieved July 2, 2009, from <http://www.nature.com/news/2009/090615/full/news.2009.571.html>
- Godlee, F. (2000). Peer review in the e-environment. Retrieved November 29, 2008, from <http://www.biomedcentral.com/meetings/2000/foi/transcripts/godlee>
- Görlitz, P. (2003). Alchema & Angewandte. *Angewandte Chemie International Edition*, 42(18), 1986–1988.
- Görlitz, P. (2004). Nothing stands still. *Angewandte Chemie International Edition*, 43(1), 4–6.
- Görlitz, P. (2005). Who is going to read all this? *Angewandte Chemie International Edition*, 44(35), 5538–5541.
- Gosden, H. (2003). 'Why not give us the full story?': Functions of referees' comments in peer reviews of scientific research papers. *Journal of English for Academic Purposes*, 2(2), 87–101.
- Hargens, L. L. (1990). Variation in journal peer review systems: Possible causes and consequences. *Journal of the American Medical Association*, 263(10), 1348–1352.
- Knorr-Cetina, K. (1981). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science*. Oxford, UK: Pergamon Press.
- Koop, T., & Pöschl, U. (2006). Systems: An open, two-stage peer-review journal. The editors of *Atmospheric Chemistry and Physics* explain their journal's approach. *Nature*, doi:10.1038/nature04988.
- Lock, S. (1985). *A difficult balance: Editorial peer review in medicine*. Philadelphia, PA: ISI Press.
- Myers, G. (1990). *Writing biology: Texts in the social construction of scientific knowledge*. Madison, WI: The University of Wisconsin Press.
- Petty, R. E., & Fleming, M. A. (1999). The review process at PSPB: Correlates of interreviewer agreement and manuscript acceptance. *Personality and Social Psychology Bulletin*, 25(2), 188–203.
- Pöschl, U. (2004). Interactive journal concept for improved scientific publishing and quality assurance. *Learned Publishing*, 17(2), 105–113.
- Roberts, L. W., Coverdale, J., Edenharder, K., & Louie, A. (2004). How to review a manuscript: A "Down-to-Earth" approach. *Academic Psychiatry*, 28(2), 81–87.
- Rowbottom, D. P. (2008). Intersubjective corroboration. *Studies in History and Philosophy of Science Part A*, 39(1), 124–132.
- Sense about Science. (2004). *Peer review and the acceptance of new scientific ideas*. London: Sense about Science.
- Simon, R. J., Bakanic, V., & Mcphail, C. (1986). Who complains to journal editors and what happens. *Sociological Inquiry*, 56(2), 259–271.
- Sonnert, G. (1995). What makes a good scientist? Determinants of peer evaluation among biologists. *Social Studies of Science*, 25(1), 35–55.
- Sperschneider, T., Kleinert, S., & Horton, R. (2003). Appealing to editors? *Lancet*, 361(9373), 1926–1926.
- Starbuck, W. H. (2005). How much better are the most-prestigious journals? The statistics of academic publication. *Organization Science*, 16(2), 180–200.
- Sternberg, R. J., Hojjat, M., Brigockas, M. G., & Grigorenko, E. L. (1997). Getting in: Criteria for acceptance of manuscripts in *Psychological Bulletin*, 1993–1996. *Psychological Bulletin*, 121(2), 321–323.
- Wager, E., Parkin, E., & Tamber, P. (2006). Are reviewers suggested by authors as good as those chosen by editors? Results of a rater-blinded, retrospective study. *BMC Medicine*, 4(1).
- Weller, A. C. (2002). *Editorial peer review: Its strengths and weaknesses*. Medford, NJ, USA: Information Today, Inc.
- Zuckerman, H., & Merton, R. K. (1971). Patterns of evaluation in science: Institutionalisation, structure and functions of referee system. *Minerva*, 9(1), 66–100.