



Scientific Peer Review

An Analysis of the Peer Review Process from the Perspective of Sociology of Science Theories

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Abstract: Although a large number of studies have been published up to now on peer review in science, only few of them employ a theory-guided approach. Most of the studies fail to connect the empirical findings to theory. The few available theory-guided empirical studies are found predominantly in the older peer review research, which was strongly influenced by the more traditional sociologists of science, referred to as the Mertonians, or the “North American school” of Robert K. Merton. The aim of the present contribution is to present a theoretical framework that includes also recent theory developments and that can serve as a basis for future empirical research on peer review. To do this, peer review is examined from the points of view of the three most important theoretical directions in the sociology of science: (1) the North American school, (2) social constructivism, and (3) social systems theory.

I. INTRODUCTION

In modern science, peer review has become the most important instrument for assessing scientific work (Ziman 2000). Through the peer review process, not only are manuscripts selected for publication but also prizes (like the Nobel Prize) and grants are awarded and jobs allocated (Hemlin and Rasmussen 2006). Beyond these, peer review is also used to evaluate

research groups and academic institutions (Hemlin 1996). With universities needing to cut costs in recent years, the trend in research project funding is that researchers can rely less and less on regular research funds from their universities and more and more have to seek external research grants that are allocated through peer review (Guston 2003).

In the typical areas of application of peer review—the review of manuscripts in-

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tended for publication and grant proposals for research funding—it is the task of the ‘reviewers’ in the review process, as ‘gatekeepers’ of science, to recommend for selection the best scientific research under the condition of scarce resources (such as limited space in journals, limited funds) (Hackett and Chubin 2003). Moreover, the reviewers are supposed to uncover errors in scientific papers and recognize scientific misconduct (Smith 2006).

For testing and legitimation of scientific work, the proponents of peer review find that the process is better suited than any other method suggested thus far (see, for example, the suggestions by Roy 1985). Active researchers in the same field of research are considered to be the persons best suited to assess the quality of their colleagues’ scholarly work (Eisenhart 2002). Critics of peer review see as a weakness of the process that (1) different reviewers’ assessments of one and the same piece of scholarly work hardly agree, (2) reviewers’ recommendations show systematic biases in judgment (the judgments are not based on the scientific quality of the work but instead on non-scientific criteria), and (3) there is little connection between peer review judgments and the quality of the reviewed work (on criticism of peer review, see, for example, Eysenck and Eysenck 1992; Ross 1980). It has been said that the only reason for continued use of the peer review process is that there is no clear consensus on a ‘better’ alternative (Young 2003).

The research on peer review, which has taken up criticism of the peer review process and examined it systematically, deals for the most part with peer review for journals (for an overview, see Campanario 1998a; Campanario 1998b; Overbeke and Wager 2003; Weller 2002) and somewhat less frequently with peer review for research and grant proposals (for an overview, see Bornmann and Daniel 2003; Demicheli and Pietrantonj 2004; Wessely

1998). There is hardly any research in other areas of application of peer review (except, for example, in Bornmann, Mittag, and Daniel 2006; Wissenschaftliche Kommission Niedersachsen 2006). And although up to now a large number of studies have been conducted on peer review—Weller (2002) considered a total of 1,439 studies for the most comprehensive literature overview of the research on manuscript review to date)—very few of the studies were conducted using a theory-guided approach (Hirschauer 2004). As Gläser and Laudel (2006:187) state, “There is a stark discrepancy between the number of empirical peer review studies and the theoretical understanding of the process.” The few theory-guided empirical studies that are available are found predominantly in the older research on peer review, which was strongly shaped by Robert K. Merton (1973) and what is called the North American school (see, for example, Cole, Cole, and Simon 1981; Cole and Rubin 1978).

In peer review research, the fact of the North American school losing its dominant position in sociology of science and being superseded by social constructivism in the late 1970s and early 1980s was connected with a transition from a more theory-guided to a more atheoretical, empirical analysis of the peer review process: “After Mertonian sociology of science had been supplanted ... the literature shifts to atheoretical, empiricist approaches by scientists and editors who were mainly interested in the validity and reliability of peer review processes” (Gläser and Laudel 2006:187).

The social constructivist sociology of science dealt with the topic of peer review only to some extent in its ethnomethodological studies (see here the few passages in Knorr-Cetina 1981; Myers 1990; see also Bedeian 2004). According to Gläser (2006), this blind spot is due to the fact that peer review is not a local interaction, observable at one locality, but instead takes place remotely as interaction

at a spatial distance. The entire process eludes ethnographic observations. Because the social constructivist and systems theory perspectives are guided by similar methodological premises, social systems theory following Luhmann (1992; 1998) has also hardly dealt with peer review up to now.

As a result of this development, the theories in sociology of science (especially the more recent theories) have remained unconsidered in empirical analysis of the scientific peer review process. The suppositions of the North American school are often viewed as outdated, and a more extensive theoretical analysis of peer review from the perspective of social constructivism and social systems theory has so far failed to appear. Therefore, the goal of the present contribution is to present a theoretical framework for peer review that also considers more recent theory developments and that can serve as a basis for future empirical peer review research.

Peer review will be analyzed from the perspectives of the three most important theoretical directions in sociology of science (see here Bornmann 2008; Cole 1992): (1) the North American school of sociology of science founded by Merton (1938), (2) social constructivism (Knorr-Cetina 1981; Latour and Woolgar 1979), and (3) Luhmann's (1992) social systems theory. Before analyzing peer review from these theoretical perspectives, the most important empirical findings of peer review research will be presented in the section just below. Based on the findings of the empirical studies, conclusions can be drawn regarding the validity of the theoretical assumptions as applied to peer review.

II. EMPIRICAL STUDIES IN PEER REVIEW

The peer review process can be conceptualized formally as a social judgment pro-

cess of individuals in a small group (for example, one or more reviewers and one or more editors of a disciplinary in-group in manuscript review) (Krampen and Montada 2002). As the peer review process can be said to be of high quality if the judgments are reliable, fair, and valid (Hackett and Chubin 2003), a large part of the studies in peer review research based the empirical analysis on these quality criteria (Daniel 1993/2004).

1. *Reliability of Peer Review*

In peer review, judgments (recommendations and decisions) on one and the same piece of scientific work are called reliable if there is a high level of agreement among the individual judgments. In peer review research the degree of agreement among the judgments of reviewers was mostly investigated in the area of review of manuscripts submitted for journal publication. All in all, the results of the studies show similar results: the coefficients measuring the inter-rater reliability among reviewers fall in the range of 0.2 to 0.4 (see an overview in Cicchetti 1991). As coefficients (kappa and intraclass correlation coefficients) below 0.5 indicate a rather low level of agreement among reviewers, this indicates that judgments in peer review are not very reliable.

Based on these numbers, Eckberg (1991) and Kostoff (1995) point out that differing judgments in peer review are not necessarily a sign of disagreement about the quality of a manuscript but may be instead explained by differing positions (paradigms), judgment criteria, and areas of competency among the reviewers. According to Cole (2000) low correlation coefficients for reviewers' judgments reflect the lack of consensus that is prevalent in all scientific disciplines at the 'research frontier.' Cole says that at the frontiers of research it is usually impossible to make a reliable assessment of scientific work. Hargens and

Herting (1990) criticize that in studies on reviewers' assessments, it is implicitly assumed that reviewers' judgments vary along one latent scientific quality dimension, and that this assumption can hardly be tested by calculating kappa or intraclass correlation coefficients. For this reason Hargens and Herting (1990) calculate row-column (RC) association models (Goodman 1984). Their investigation of manuscript review for five journals shows that at four of the journals, it can be assumed that one quality dimension accounts for the association in the reviewers' judgments. In contrast to the findings of the other studies on the reliability of peer review, Hargens and Herting's (1990) results thus indicate that there is a substantial statistical association among reviewers' judgments (see also Bornmann, Mutz, and Daniel 2007).

Although a high level of agreement among the reviewers in the peer review process is striven after, some scientists see high agreement at the same time as disadvantageous to the review process: "Too much agreement is in fact a sign that the review process is *not* working well, that reviewers are not properly selected for diversity, and that some are redundant" (Bailar 1991:138). According to Marsh and Ball (1991) the selection of reviewers that represent diverse perspectives, use different judgment criteria, and so on, reduces reliability. But validity can be increased considerably, as the decision-makers (such as journal editors or grant program managers) can make their decisions about a manuscript or proposal based on much broader information. For this reason, in the opinion of researchers that see low reliability as helpful for the decision-making process, reviewers should be selected precisely because of their different perspectives, judgment criteria, and so on (Stricker 1991).

2. *Fairness of Peer Review*

Overviews of the peer review research

literature (Hojat, Gonnella, and Caellegh 2003; Owen 1982; Pruthi, Jain, Wahid, Mehra, and Nabi 1997; Ross 1980; Sharp 1990; Wood and Wessely 2003) have named up to 25 different biases that can potentially endanger the fairness of the peer review process. Bias is usually defined as follows: "Bias is any feature of an evaluator's cognitive or attitudinal mind-set that could interfere with an objective evaluation" (Shatz 2004:36). Even if numerous studies have reported a lack of fairness in the peer review process, the research on fairness faces two fundamental problems that make generalization of the findings difficult. For one, the published results on the influence of the individual biases on reviewers' judgments are inconsistent. For instance, numerous studies demonstrated gender bias in the peer review of research and grant proposals (for example, Brouns 2000; Wenners and Wold 1997). However, a similar number of studies were able to identify only a moderate gender effect or none at all (for example, Sandström and Hällsten 2006; Ward and Donnelly 1998) or reported mixed results (for example, Bornmann and Daniel 2005). For another, as there are no experimental studies in the research on peer review, it is impossible to establish whether a particular group of scientists (such as, for example, grant applicants or manuscript authors at less prestigious universities) receive worse reviews due to preferential biases on the part of the reviewers or whether the unfavorable reviews are the consequence of the insufficient quality of the proposals or manuscripts (Daniel 1993/2004).

3. *Predictive Validity of Peer Review*

The goal of peer review of grant applications and manuscripts is usually to select the 'best' from among the work submitted (Smith 2006). The selection function is considered to be a difficult research topic to investigate. According to Jayasinghe, Marsh, and Bond (2001) there exists no uniform

definition of what makes a manuscript 'worthy of publication,' or of what makes a research proposal 'worthy of funding.' But as the number of citations of a publication reflects the international impact of the reported research (Daniel 2005; van Raan 2004), it is a common approach in peer review research to evaluate the success of the process on the basis of the citation rate of the reviewed research.

Bornmann and Daniel (2008), Daniel (1993/2004), Lock (1985), Wilson (1978) and Opthof, Furstner, van Geer, and Coronel (2000) examined the predictive validity of peer reviewing of manuscripts based on the citation counts of manuscripts accepted for publication and manuscripts rejected by a journal but then published elsewhere. The results of all of these four studies show unanimously that manuscripts accepted and published by *Angewandte Chemie*, *British Medical Journal*, *Journal of Clinical Investigation*, and *Cardiovascular Research* are clearly more frequently cited than manuscripts that were rejected by these journals and later published elsewhere.

III. PEER REVIEW FROM THE POINT OF VIEW OF SOCIOLOGY OF SCIENCE THEORIES

In the following sections, the theoretical assumptions of the North American school of sociology of science, social constructivism, and social systems theory are presented in a first step. In a second step, the assumptions are applied to the peer review process.

1. *The Point of View of the North American School on Peer Review*

With the "ethos of science" Merton (1973) conceptualized in the tradition of structural functionalism the (positive) norms and values of science that are held to characterize appropriate and correct be-

havior on the part of scientists: (1) scientific knowledge should be made public knowledge (communism, or communality), (2) the scientist forgoes all forms of personal gain (disinterestedness), (3) knowledge must always be scrutinized (organized skepticism), and (4) knowledge claims should be judged impersonally, independently of their source (universalism). Since the beginnings of modern science, the ethos of science has developed in the interaction of (professional) scientists (Merton 1973). As prescriptive norms (see Coleman 1990) the norms prescribe certain behaviors and create an implicit scientific conscience. As imperatives, the norms are internalized by scientists today through socialization in scientific institutions (Merton 1973).

For Merton (1973) the peer review process is an institutional guarantor that science will be oriented towards the prescriptions and principles of practicing 'good' science—the ethos of science. Only with an institutionalized form of assessment (that is, with a recognized quality assurance system) can science make a claim to being that functional system in society that is responsible *exclusively* for knowledge production and knowledge accumulation (Hansson 2002). Two of the four norms in the ethos of science play a particularly important role in the analysis of the peer review process: (1) the norm of universalism, and (2) the norm of organized skepticism (the norms of communism and disinterestedness have more to do with guaranteeing unrestricted access to research findings):

With the norm of universalism being operative in peer review, the aim is to prevent economic, political, religious, or other non-scientific interests from influencing the process of selecting a scientific paper or a grand proposal and thus the process of knowledge gain (Ziman 2000). If scientists are to assess the work of a colleague in their field through a process of peer review, they are encouraged to base their judgments exclusively on scientific quality criteria and

not to draw up any irrelevant criteria (on this, see Cole 1992). The most suitable persons for assessing others' work according to scientific quality criteria are successful colleagues of the scientist whose work is being reviewed (grant applicant or author of a manuscript, see on peer review the findings by Jayasinghe 2003). When assessing the scientific quality of a proposal or manuscript, for the reviewer the correspondence of the research results with the 'laws of nature' plays a decisive role, as reviewers assess as positive only those facts that agree with the 'laws of nature' (Cole 1992). The norm of universalism in peer review would, finally, result in acceptance and communication of knowledge independently of the local and social conditions of knowledge production (in the laboratory) or selection (in peer review) (Ziman 2000).

With the norm of organized skepticism being operative in peer review, it could be guaranteed that new findings have to be put up for debate among experts until, once assessed positively, they are ascribed a recognized degree of credibility and certainty. Through the norm of organized skepticism, only knowledge that is tested thoroughly and authorized by specialist colleagues would flow into the body of knowledge and inform the further knowledge utilization in a specialist field. Thus, as a result of the workings of the norm of organized skepticism, knowledge that is legitimized and thus capable of consensus (Ziman 1991) would ultimately produce a high level of agreement in a specialized area of study. For the followers of the North American school, a high level of consensus in the process of knowledge construction is an important prerequisite to ensure in a field of inquiry the sustainable accumulation of verified knowledge (Mulkay 1969).

According to Merton (1973) norms take the form of rules, prohibitions, and principles that determine what conduct is to be favored and what is permissible. In peer review the rules and principles for good sci-

entific conduct are imposed by means of sanctions. These sanctions are predominantly of an incremental type (on this, see Coleman 1990): Where there is proof of a scientist's intentional misconduct, that scientist is (collectively) 'cut off.' That these sanctions exist is shown by the many recommendations lists concerning conduct that scientific institutions have published for the prevention of and for dealing with scientific misconduct (see, for example, European Association for Chemical and Molecular Sciences 2006). Following Merton (1973) attacks on the integrity of science show that science has to rely on these sanctions so that the process of knowledge gain is not endangered.

A part of the studies in peer review research (see above, Empirical Studies in Peer Review) contains indications that the assumptions of the North American school of sociology of science can indeed adequately describe scientists' conduct in the peer review process: (1) The studies conducted by Hargens and Herting (1990) show that reviewers judge manuscripts according to a uniform scientific quality dimension. This consensus about quality seems to show that the two norms (universalism and organized skepticism) are operative in peer review. (2) Up to now no investigations *having an experimental study design* have been conducted on fairness in peer review that were able to demonstrate without a doubt systematic biases in judgment. Indeed, the conduct of reviewers, editors, and program managers does seem to be guided by the norm of universalism. (3) The studies on predictive validity make it clear that editors and reviewers can assess the scientific impact of manuscripts correctly: Rejected manuscripts published later elsewhere have distinctly lower citation counts than manuscripts accepted for publication. The finding that the review process is oriented towards the scientific quality (or the possible impact) of a piece of research can again be seen as showing that the two norms are

operative in peer review.

2. The Social Constructivist Point of View on Peer Review

The followers of social constructivism among the sociologists of science reject the theoretical assumptions of the North American school—in particular the existence of the norms that Merton (1973) summed up in the ethos of science—and replace them with their own assumptions (for an overview, see here Mulkay 1979). In the following, the most important assumptions of the social constructivists are described in a first step and applied to peer review in a second step. As we will see, the theoretical assumptions show a recognizable relation to criticism that has been directed at traditional peer review (whose principles are shaped by the North American school) for years (see introduction above).

First assumption: Scientific behavior is not governed by the norms that Merton identified and set out as the ethos of science.

The followers of social constructivism are convinced that science is not steered by norms. They base this conviction on a number of microsociological studies (see, for example, Knorr-Cetina 1981). These studies do not provide indications that (1) scientists try to follow certain norms in their behavior and that (2) the behavior of scientists can be satisfactorily explained by the ethos of science (Knorr-Cetina 1991). Scientific conduct is therefore seen as not conforming to norms. From this assumption of the independency of scientific conduct and normative prescriptions, the followers of social constructivism derive the hypothesis that normatively guided behavior is *not* a necessary prerequisite for the process of knowledge construction and scientific progress.

A number of studies have been conducted in peer review research that examined the behavior of scientists in peer review against the background of the norms

of the ethos of science. All of the studies on fairness in peer review (see the section on empirical studies above), for example, tested implicitly or explicitly the norm of universalism in the peer review process. The results of some of these studies indicate that judgments in the peer review process are systematically influenced by non-scientific criteria, such as gender. In one of the best-known studies, the results of which were published in the journal *Nature*, Weners and Wold (1997) demonstrate for the peer review process at the Swedish Medical Research Council (MRC; Stockholm) that a woman must be approximately 2.5 times more productive scientifically (through publications in high-quality journals) than a man in order to receive the same judgment by the reviewers.

While studies such as that by Weners and Wold (1997) call into question that scientists' behavior in peer review behavior conforms to norms, the results of a study (Ellison, Rosato, and Outram 2005) presented at the Fifth International Congress on Peer Review and Biomedical Publication (Chicago, USA) in 2005 make it clear, moreover, that scientists are hardly willing to align their behavior to institutionally decreed principles and regulations. The study investigated the extent to which authors publishing articles in the *British Medical Journal (BMJ)* followed the journal's ethical guidelines. The researchers found the following: "It is clear that the *BMJ*'s 'guidelines on the use of ethnic, racial, and cultural descriptions in published research' have not been followed" (Ellison, Rosato, and Outram 2005).

Second assumption: Scientists do not own the privilege of participation in the scientific discourse in their field of science.

According to the assumptions of the North American school of sociology of science, scientists acquire specific knowledge and abilities in their field through long years of university studies and research activity that certify them as experts in that

field (Collins and Evans 2002). Due to this knowledge and abilities, it is ultimately only experts like this that can conduct the scientific discourse in a field of expertise at an appropriate level. The social constructivists contradict this assumption and deny the experts in a given specialist field the sole privilege of participating in the scientific discourse (see here Fuchs 1996). It might seem that anyone can be an expert (Collins and Evans 2002:238). Also outsiders (persons or scientists outside of the specialism), who may indeed lack technical or mathematical understanding in a field but who are familiar with the contents, theories, and technical terminology, may participate, similar to those possessing expertise, in the scientific discourse.

In an experiment conducted by Harry M. Collins—one of the most influential researchers among the social constructivists—and reported in the journal *Nature* (Giles 2006), it could be shown that an expert's answers to questions in his area of expertise (gravitational wave physics) could not be distinguished from the answers given by an outsider (a social scientist) passing himself off as a physicist: "The experiments show that the linguistic performance of those well socialized in the language of a specialist group is indistinguishable from those with full blown practical socialization but distinguishable from those who are not well socialized" (Collins, Evans, Ribeiro, and Hall 2006:656).

Another study, which was presented in 2005 at the Fifth International Congress on Peer Review and Biomedical Publication (Chicago, USA), called into question the privilege of experts to take part in the peer review process: Bryan, Fletcher, and Kale (2005) examined whether a nonqualified but experienced member of the *BMJ* editorial administrative team makes final decisions on submitted manuscripts similar to the *BMJ* editors' decisions made within a particular time period based on reviewers' recommendations. The results show that

the staff member would make the same decision on 90% of the manuscripts originally rejected by the editors and would accept for publication only 10% of the papers that the editors reject.

The findings by Collins, Evans, Ribeiro and Hall (2006) and Bryan, Fletcher, and Kale (2005) contradict the assumption of the North American school that active scientists within the same field of research are the best suited persons—in accordance with the norm of organized skepticism—to assess the work of colleagues in their fields as to scientific quality. Outsiders (persons or scientists outside of the specialism) that are familiar with the contents, theories, and technical terminology can arrive at similar judgments.

Third assumption: Scientific knowledge does not reflect 'natural reality' but is instead constructed socially and locally.

One of the most important assumptions of social constructivism is that scientific insights are social and local constructions (Knorr-Cetina 1991). Scientific knowledge does not reflect any 'natural reality' but instead is manufactured in the research process under the given local conditions (Knorr-Cetina 1981). These conditions include the cultural and social contexts, and also the scientists' personal interests, social relationships, and biases in judgment. In order to describe the processes of the context-specific construction on knowledge, social constructivists make use of concepts such as social situatedness, contextuality, interpretative flexibility, opportunistic rationality, and local idiosyncrasies (Krohn 2000).

For social constructivists, 'laws of nature' and 'truth' play little role not only in the process of knowledge acquisition but also in the peer review process. Favorable and unfavorable assessments by reviewers, editors, and grant program managers are said to be (exclusively) the result of social processes and local conditions. Those involved in a peer review process make their

assessments upon the background of their personal biographies, individual interpretations of specialized knowledge of their subject, the social network, and the local conditions under which they work (Gläser and Laudel 2006).

For Cole (1992) the low level of agreement among reviewers reported by some of the studies on peer review substantiates the social constructivist assumption that it is not the scientific validity of a work but rather local and social conditions that determine the judgments (see above, Reliability of Peer Review): "If consensus can be determined by comparing a contribution with nature or by the application of a set of rational rules to evaluate the validity of a contribution, why do we find little consensus?" (Cole 1992:83). Also the many biases in judgment that are discussed in connection with peer review (see above, Fairness of Peer Review) give rise to doubt as to whether there can be objective review without local and social influences.

The results of the studies on predictive validity (see above, Predictive Validity of Peer Review) show, on the one hand, that manuscripts accepted for publication have a greater impact on subsequent research than rejected manuscripts published later elsewhere. The peer review process thus seems to fulfill its function of selection between 'successful' and 'unsuccessful' research. On the other hand, studies on predictive validity demonstrate that in the peer review process of one and the same manuscript, reviewers arrive at different judgments: Many manuscripts that are rejected by a journal (through a peer review process) are then accepted by another journal (through a peer review process). This finding indicates that manuscript review is *not* only based on generally valid quality criteria that a scientific work can fulfill (acceptance) or not fulfill (rejection); the review (or the outcome of the review) seems also to be dependent upon the local and social conditions under which the peer re-

view process at the individual journals takes place.

Fourth assumption: Scientific work is a social construction of the scientist under review and the reviewers.

For the followers of the North American school, manuscripts are the result of scientists' research work, who by submitting manuscripts to journals seek to secure ownership of their intellectual property with sole rights to recognition (Merton 1973). The followers of social constructivism contradict this assumption. To them, it is not only the author that is responsible for the content of a manuscript (and has rights to the intellectual property); the content of a manuscript is a joint product by the author, reviewer, and editor (on this perspective extended to research project proposals, see Laudel 2006). Authors anticipate the peer review process already while writing (Knorr-Cetina 1981), and in the review process reviewers and editors seek to realize personal interests with regard to the content of manuscripts (Gläser 2006; Gläser and Laudel 2006). The theoretical assumption that in the peer review process a manuscript is socially constructed by both the scientists under review *and* the reviewers was developed by social constructivists based on observations of the research and publication process (Knorr-Cetina 1981) as well as on analyses of manuscripts and reviewers' assessments (Myers 1990).

3. The Social Systems Theory Point of View on Peer Review

Sociologists working within the North American school framework and the social constructivism framework have always tended to reject each other's positions (see here, for example, Knorr-Cetina 1991; Sokal and Bricmont 1999), although some papers proposing a mediating position have been published (for example, Murphy 1994). Krohn (2000) sees great potential in Luhmann's (1992) social systems theory to

overcome the crisis of the social studies of science that arose due to the theoretical fragmentation. By considering the perspective of an observer, Luhmann (1992) maintains the difference that the constructivists make between knowledge and object. For Luhmann knowledge is the construction of distinctions, whereby that which is distinguished has no direct correspondence in reality. In contrast to the social constructivist approach (and following the North American school), science is for Luhmann (1992) characterized by a specifically shaped form of communication that is oriented to 'truth.' Through this orientation, science distinguishes itself from its surroundings as a functionally differentiated system and can remain an autonomous system.

In his analysis of science, Luhmann (1992) utilized two components from social systems theory that are said to be fundamentally important in the construction of solid knowledge (see here also Leydesdorff 2001): 1) second-order observation, and 2) the evolution of knowledge. In contrast to the theoretical assumptions of the North American school and the social constructivists, these components are *not* mechanisms that seek to explain the (specific) phenomena in science through the actions of persons in social contexts. Instead, these components can fundamentally describe the course of scientific communication and point out the central importance of review and selection in the process.

According to social systems theory, science is differentiated as a societal subsystem that is an autopoietic system having the function of producing knowledge of high certainty (Luhmann 1992). Autopoietic systems are recursive, operatively closed systems—there are no operations entering the system from the environment and vice versa. The operative element of science is the communication of knowledge that is reproduced in the symbolically generalized medium of 'truth' (Stichweh 1994). Communication can be called specifically

scientific, only if it is used to establish a distinction (the binary code) of 'true' and 'not true.' With the attribution of 'true,' it is symbolized in the system that a finding can be held to be generalizable statement of reality.

1) *Second-order observation.* Luhmann (1992) bases the theory of social systems on a formal concept of observation that goes back to Spencer-Brown (1969). Spencer-Brown (1969) developed the *Laws of Form*, according to which every observation is constructed of two components (indication and distinction), which can explain all possible operations of an observer: The basis of all indications is a distinction drawn by an observer between inside and outside. In this process, there is no complete and consistent system of description available to the observer—that is, "no observation can observe what it cannot observe" (Fuchs 1996:321). Once having drawn the distinction, the observer has a 'blind spot,' seeing only one side of the distinction, which is then discernible only through observation of a higher order. As every observation is fraught with a blind spot, no 'better' description of reality can be expected with every further observation of a higher order than with the observation of a lower order.

Luhmann (1992) applied the formal concept of observation to the process of knowledge production in science. Since the natural world cannot speak for itself (Gieryn 1982:288), in the research process one has to rely on generating knowledge through a first-order observation that can claim to explain a certain natural phenomenon (or social phenomenon). As the observation can only refer exclusively to the phenomenon and not to the observation itself, it can only be called naive realistic and not constructivist (Fuchs 1996): The first-order observer can not forgo the assumption of reality; the first-order observer draws distinctions in an object world (Schmidt 1998). If the observation is formulated as a knowledge claim, it can be coded, through a sec-

ond-order observation, as 'true' (verified) or 'not true' (not verified).

"On the second level, communication must decide, amongst other issues, which observations are relevant and deserve being noticed by others," states Fuchs (1996:317). Findings (from first-order observation) are as a rule described in manuscripts and submitted to scientific journals for review. Through second-order observation (critical assessment), peers code the findings as 'true' or 'not true' (or verified or not verified). As the attribution of 'true' or 'not true' can be made only by second-order observation (and *not* by first-order observation in an object world), it is therefore only through critical assessment that it can be guaranteed that science produce the substantiated knowledge that society expects of it in fulfillment of its function. Only at the level of second-order observation can the binary code of 'true'/'not true' unfold and science differentiate itself as a system (Luhmann 1992).

2) *The evolution of knowledge.* For the analysis of science, Luhmann (1992) applied the theory of evolution to the process of the generation of (verified) knowledge, with the main elements of evolutionary theory as variation, selection, and stabilization. Science produces vast amounts of findings with a high degree of *variation*. Here we have the global supply of findings that can contribute towards explanation of natural and social phenomena. The great range of variation of the findings means that more findings are produced in science than are capable of reception. For this reason, in the process of selection a part of the findings are taken up in communication and marked as 'true' (the other part is not taken up and marked as 'not true'). In science, the (critical) selection process is undertaken by the peer review process. Another selection process, downstream of peer review, is the utilization (or the ignoring) of findings and thinking in the further research work in a field of study, which

finds expression in citation by colleagues in the field. Through the rejection of manuscripts, research proposals, and so on, in peer review, only a part of the findings is given the possibility to be taken up in the body of knowledge, or to be further utilized, in a field. The other part does not clear the 'hurdle' of peer review and is subject to the fate of being forgotten. With the selection of scientific work, peer review at the same time can fulfill the function of stabilization (of knowledge) in science. According to Luhmann (1992), in the evolutionary process, *stabilization* is the tendency in the system to largely avoid changes in the body of knowledge and to maintain the previous body of knowledge, or to persist in the state of the previous structure. In the end, the only new findings that can get past the stabilizing tendencies in the system as substantiated knowledge are those that stand out sufficiently and prove to be 'true' intersubjectively.

IV. DISCUSSION

In the above, peer review was analyzed from the points of view of the three most important theoretical directions in sociology of science: (1) the North American school, (2) social constructivism, and (3) social systems theory. In the face of the inconsistent findings in peer review research (see above, Empirical Findings), in the analysis of peer review from the points of view of the North American school and social constructivism, empirical results (as a rule from studies having a strict methodology) could be found *in each instance* that could support diametrically opposed theoretical assumptions. The inconsistent findings in peer review research thus reflect the theoretical fragmentation in sociology of science (and vice versa).

The empirical validation of the assumptions of *both* theoretical directions (as they were shown in the sections above) can

in the end support those sociology of science contributions that have proposed a mediating position between the two theoretical directions (see, for example, Murphy 1994). As the components from social systems theory (second-order observation and evolution of knowledge) that were utilized in this paper for the analysis of peer review are 'abstract' communication processes (with no direct relation to the level of the conduct of scientists), no empirical results from peer review research could be used to validate these processes.

With the analysis of peer review from the perspectives of the three theoretical directions, a theoretical framework was gained for the empirical investigation of peer review, which can be summarized as follows: For the description of fundamental processes in peer review, second-order observation and the evolution of knowledge can be utilized. In the course of scientific communication, these components can show in what way assessment in peer review and selection by means of peer review can contribute towards fulfilling continuously the specific function of science for society—the generation of *verified* knowledge. Verified knowledge is only then generated, if (1) second-order observations of (not verified) findings are coded as 'true' and 'not true' (assessment in peer review), and (2) under the condition of scarce resources, a part of the knowledge is selected out of a reservoir that is rich in variation (selection by means of peer review).

For the analysis of peer review, in addition to second-order observation and the evolution of knowledge (at the level of communication in science), (1) the norms in the ethos of science and (2) the assumptions of the supporters of social constructivism (at the level of the conduct of scientists) were utilized. The norms of universalism and organized skepticism are held to be imperative for the disciplining of the conduct of scientists. This disciplining can (and should) lend stability to that system of as-

essment and selection that is continuously generated through second-order observation and the evolution of knowledge. Norms can (and should) lead to 'control' of scientists' conduct according to the principles of 'good' scientific practice, in that they work against particularism (the operative effect of universalism) and guarantee the intersubjectivity of knowledge construction (the operative effect of organized skepticism). The theoretical assumptions of the followers of social constructivism point on the one hand to the necessity to discipline the conduct of scientists by peer review. Adherence to the norms—as the results of the microsociological research and a part of the studies in peer review research show clearly—is not a matter of course; conduct deviating from the norms must be reckoned with. On the other hand, the microsociological research of the social constructivists makes it clear that the local and social conditions under which scientists work can have a decisive influence on the review process: "'Facts' needed long construction and acceptance procedures" (Evetts, Mieg, and Felt 2006:116).

By pointing out scientific conduct deviating from norms and the local and social conditions of the review process, we can see the theoretical assumptions of the social constructivists, on the one hand, as a complement to the assumptions of the North American school that leads to a 'denser' (that is, fuller) description of the conduct of scientists in peer review (see here Collins and Evans 2002; Gilbert and Mulkay 1984). On the other hand, the assumptions of the social constructivists show that certain conditions that are viewed in traditional peer review as necessary for a 'successful' assessment process are subject to flexibility and variability: (1) Assessments do not necessarily have to be undertaken by peers (experts), and (2) not only the reviewed scientist (author or grant applicant) but also the reviewing scientist (reviewer, editor, or grant program manager) contributes in the

peer review process towards the coming into being of a scientific work. Recognition for the content of a scientific work is due therefore not only to the author or grant applicant but also to the reviewer.

With the assumptions of the social constructivists, the North American school, and social systems theory, we come to a description of processes of communication and conduct that are fundamental for the conducting of peer review in science, which has become a functionally differentiated subsystem in society for the production of verified knowledge. The assumptions of the three most important theoretical directions in sociology of science are a valuable basis for in-depth, theoretically founded examination of the (future) findings of peer review research.

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