What do citation counts measure? A review of studies on citing behavior

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Abstract

Purpose – The purpose of this paper is to present a narrative review of studies on the citing behavior of scientists, covering mainly research published in the last 15 years. Based on the results of these studies, the paper seeks to answer the question of the extent to which scientists are motivated to cite a publication not only to acknowledge intellectual and cognitive influences of scientific peers, but also for other, possibly non-scientific, reasons.

Design/methodology/approach – The review covers research published from the early 1960s up to mid-2005 (approximately 30 studies on citing behavior-reporting results in about 40 publications).

Findings – The general tendency of the results of the empirical studies makes it clear that citing behavior is not motivated solely by the wish to acknowledge intellectual and cognitive influences of colleague scientists, since the individual studies reveal also other, in part non-scientific, factors that play a part in the decision to cite. However, the results of the studies must also be deemed scarcely reliable: the studies vary widely in design, and their results can hardly be replicated. Many of the studies have methodological weaknesses. Furthermore, there is evidence that the different motivations of citers are "not so different or 'randomly given' to such an extent that the phenomenon of citation would lose its role as a reliable measure of impact".

Originality/value – Given the increasing importance of evaluative bibliometrics in the world of scholarship, the question "What do citation counts measure?" is a particularly relevant and topical issue.

Keywords Reference services, Bibliographic systems

Paper type Literature review

Introduction

In 1927, a pioneering paper published by Gross and Gross (1927) was the first to use citation counts to evaluate the importance of scientific work. Since then, citation analyses have been conducted for assessment of national science policies and disciplinary development (e.g. Oppenheim, 1995, 1997; Lewison, 1998; Tijssen *et al.*, 2002), departments and research laboratories (e.g. Narin, 1976; Bayer and Folger, 1966), books and journals (e.g. Garfield, 1972; Nicolaisen, 2002), and individual scientists (Garfield, 1970;, e.g. Cole and Cole, 1973). In these studies the number of citations of peer reviewed papers was used to measure the impact of the work of scientists on the scientific community, as high quality work by a scientist will trigger more responses (citations) from scientific colleagues than low quality work (Van Raan *et al.*, 2003; Cawkell, 1968).

Citation counts are attractive raw data for the evaluation of scientific performance, as they are "unobtrusive measures that do not require the cooperation of a respondent and do not themselves contaminate the response (i.e. they are non-reactive)" (Smith,

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1981, p. 84). However, researchers interested in measuring scientific impact are split into two camps. According to one camp (e.g. Cole, 2000; Van Raan, 2004a), evaluative bibliometric analyses are suitable for the assessment of scientific results, as a substantial body of literature has shown that the number of citations to scientists' publications are correlated with other assessments of scientists' impact or influence, such as awards, honors, and Nobel laureateships (e.g. Myers, 1970; Cole and Cole, 1967, 1968, 1971; Inhaber and Przednowek, 1976), departmental prestige (e.g. Anderson *et al.*, 1978; Hagstrom, 1971), research grants (e.g. Hagstrom, 1971), academic rank (e.g. Cole and Cole, 1972), and peer judgments (Smith and Eysenck, 2002; Cole, 1975; Crane, 1972; Lawani, 1986; Bornmann and Daniel, 2005; Daniel, 1993, 2004; Christensen-Szalanski and Beach, 1984; Simonton, 1992; Cole, 1989; Rinia *et al.*, 1998;, e.g. Aksnes and Taxt, 2004; Lawani and Bayer, 1983). Referring to "citations as proxies," Cronin (2005a, pp. 125–129) lists in an overview further studies on the association between citations to scientists' publications and other assessments of the scientists' scientific impact or influence.

The other camp interested in impact measures doubts that citation counts can reflect the impact of scientific activity (see, e.g. Woolgar, 1991). These authors base this assessment on statements such as those by Garfield (1972), the founder of the Institute of Scientific Information (ISI, now Thomson Scientific, Philadelphia, PA, USA), according to which citation counts are a function of many variables besides scientific impact. That is, this camp holds that the probability of being cited depends on many factors that do not have to do with the accepted conventions of scholarly publishing:

- *Time-dependent factors*. Due to the exponential increase in scientific output, citations become more probable from year to year. More citations to recent than to older publications can be expected, because there are more of them (Cawkell, 1976). Beyond that, it has been shown that the more frequently a publication is cited, the more frequently it will be cited in future; the expected number of future citations is a linear function of the current number (Cano and Lind, 1991; Garfield, 1981; Burrell, 2003; Rabow, 2005)[1]. Cozzens (1985) calls this phenomenon "success-breeds-success," and it is found not only for highly-cited publications, but also for highly-cited scientists (Garfield, 2002, see also Merton, 1968, Price, 1976).
- *Field-dependent factors*. Citation practices vary between science and social sciences fields (Hurt, 1987; Bazerman, 1988; Hargens, 2000; Braun *et al.*, 1995a, b; Ziman, 2000) and even within different areas (or clusters) within a single subfield (Lewison and Dawson, 1998; Klamer and Van Dalen, 2002). In some fields, researchers cite recent literature more frequently than in others (Peters and Van Raan, 1994). As the chance of being cited is related to the number of publications in the field (Moed *et al.*, 1985), small fields attract far fewer citations than more general fields (King, 1987).
- *Journal-dependent factors*. Stewart (1983) argue that the citation of an article may depend on the frequency of publication of journals containing related articles. According to Laband and Piette (1994) and Smart and Waldfogel (1996), there is some evidence that the order in which an article is listed in a journal issue matters considerably for the influence that the article gathers. More precisely, the first article in a scientific journal tends to produce more citations than later ones

(Ayres and Vars, 2000). Furthermore, journal accessibility, visibility, and internationality (Vinkler, 1987, Yue and Wilson, 2004) as well as the impact, quality, or prestige of the journal may influence the probability of citations (Moed *et al.*, 1985; Seglen, 1989; Cronin, 1984; Tainer, 1991; Meadows, 1998; Van Dalen and Henkens, 2005; Boyack and Klavans, 2005).

- *Article-dependent factors*. Citation characteristics of methodology articles, review articles, research articles, letters, and notes (Shaw, 1987; Cano and Lind, 1991; MacRoberts and MacRoberts, 1996) as well as articles, chapters, and books (Bott and Hargens, 1991) differ considerably. There is also a positive correlation between the citation frequency of publications and the number of co-authors of the work (Beaver, 2004; Lawani, 1986; Baldi, 1998), and the number (Peters and Van Raan, 1994) and the impact (Boyack and Klavans, 2005) of the references within the work. And, as longer articles have more content that can be cited than shorter articles do, the sheer size of an article influences whether it is cited (Abt, 1993; Baldi, 1998; Stewart, 1990; Laband, 1990).
- *Author/reader-dependent factors*. The language a paper is written in (Cronin, 1981a, Lawani, 1977; Liu, 1997; Kellsey and Knievel, 2004; Van Raan, 2005a) and culture barriers (Carpenter and Narin, 1981, Menou, 1983) influence the probability of citations[2]. Results from Mählck and Persson (2000), White (2001), and Sandström *et al.* (2005) show that citations are affected by social networks: authors cite primarily works by authors with whom they are personally acquainted. Cronin (2005a) finds this hardly surprising, as it is to be expected that personal ties become manifest and strengthened, resulting in greater reciprocal exchange of citations over time.

  Studies by Cole and Singer (1991) and Baldi (1998) show that men receive substantially more citations to their work than women do. Possible reasons for this gender gap are put forward by Meadows (1998) and Stack (2004).
- *Availability of publications*. Physical accessibility (Soper, 1976), free online availability of publications (Lawrence, 2001), and the publishing media (Silverman, 1985) influence the probability of citations.
- *Technical problems*. Citation analyses cannot be any more accurate than the raw material used (Smith, 1981, Van Raan, 2005a). The incorrect citing of sources is unfortunately far from uncommon: Evans *et al.* (1990) checked the references in papers in three medical journals and determined that 48 percent were incorrect: "The data support the hypothesis that authors do not check their references or may not even read them" (Evans *et al.*, 1990, p. 1353). In a similar investigation, Eichorn and Yankauer (1987) found that "thirty-one percent of the 150 references had citation errors, one out of 10 being a major error (reference not locatable)" (p. 1011). Broadus (1983) estimates a range of 10-60 percent for references that contain some error.

  Additionally, problems stemming from homographs and synonyms can arise when researching publications and deriving citations from citation databases using authors' names (MacRoberts and MacRoberts, 1989a, 1996, Cole and Cole, 1971).

However, according to Cronin (1982) the central problem of citation counts for measuring research impact is that norms and conventions of citation are not precisely formalized, which is why it is uncertain what is being measured (see also Cano, 1989). Citation counts do not yield insight into the authors' motives for their citing behavior, nor do they tell us what informational unit they are targeting in the cited work (Brooks, 1985)[3]. Authors use citations with different intentions and meanings (Garfield, 1998). The use of citation counts as an indicator for research impact is appropriate only when the citation of a document means that the citing author used that document; the citation of a document reflects the merit (quality, significance, impact) of that document; and citations are made to the best possible works (Smith, 1981). To date, a large number of studies have investigated the question as to the extent to which scientists cite works based on those premises or whether they are motivated by other factors to cite certain publications; those studies are presented in the following sections. With the increasing importance of evaluative bibliometrics in the world of scholarship (Swinbanks *et al.*, 1997; Deutsche Forschungsgemeinschaft, 1998; Van Raan, 2005b), the issue is becoming particularly relevant and topical. The goal of empirical studies analyzing citation behavior has been not only to reveal authors' motivations for citing publications but also to improve the use of citation counts in research evaluation[4].

Earlier reviews on the role of citations and their possible classifications are given by Cronin (1984), Liu (1993a), and Small (1982). As these reviews were published more than ten years ago, there is a need to consider more recent studies. Nearly half of the studies (48 percent) that our search of the literature revealed for the topic of "citing behavior" and that we included in the present review were published from the early 1990s up to mid 2005, while 52 percent of the studies were published between the early 1960s and the late 1980s. Before presenting (in section 3 below) approximately 30 studies on citing behavior (reporting results in about 40 publications), organized by the research method used (2.2 Context analyses of citations in citing documents, 2.3 Content analyses of citations to characterize the cited work, 2.4 Citer motivation surveys or interviews, 2.5 Studies on the motivations of scientists for non-citing), we will first look at theoretical approaches to explaining citing behavior in section 2 below[5].

1. Theoretical approaches to explaining citing behavior

Two competing theories of citing behavior have been developed in past decades, both of them situated within broader social theories of science. One is often denoted as the normative theory of citing behavior and the other as the social constructivist view of citing behavior.

The normative theory, following Robert K. Merton's – the founder of the modern sociology of science – sociological theory of science (Merton, 1973), basically states that scientists give credit to colleagues whose work they use by citing that work. Thus, citations represent intellectual or cognitive influence on scientific work. Merton (1988) expressed this aspect as follows: "The reference serves both instrumental and symbolic functions in the transmission and enlargement of knowledge. Instrumentally, it tells us of work we may not have known before, some of which may hold further interest for us; symbolically, it registers in the enduring archives the intellectual property of the acknowledged source by providing a pellet of peer recognition of the knowledge claim,

accepted or expressly rejected, that was made in that source" (Merton, 1968, p. 622, see also Merton, 1957).

According to Small (1978, 1982) the cognitive symbol, or the content concept, that links citing scientists to a particular work can be studied through content analysis of the citation context. Over a set of citing documents, the percent uniformity (the degree to which citing scientists demonstrate consensus on the nature of the cited concept) can be calculated to identify the ideas symbolized by the cited work. Other than Small (1978), only a few studies have actually used this approach to characterize the concept symbol nature of cited works by examining the content of the citation context (for an overview, see McCain and Salvucci, 2005). Owing to the intellectual and cognitive influence that can be ascribed to a citation, the normative framework sees evaluative bibliometric analyses as appropriate for the assessment of scientific results.

The social constructivist view on citing behavior is grounded in the constructivist sociology of science (see, e.g. Collins, 2004; Knorr-Cetina, 1981; Latour and Woolgar, 1979). This view casts doubt on the assumptions of normative theory and questions the validity of evaluative citation analysis. Constructivists argue that the cognitive content of articles has little influence on how they are received. Scientific knowledge is socially constructed through the manipulation of political and financial resources and the use of rhetorical devices (Knorr-Cetina, 1991). For this reason, citations cannot be satisfactorily described unidimensionally through the intellectual content of the article itself. Scientists have complex citing motives that, depending on the intellectual and practical environment, are variously socially constructed (e.g. to defend their claims against attack, advance their interests, convince others, and gain a dominant position in their scientific community). The British sociologist Gilbert (1977), who has been particularly associated with the constructivist view of citing behavior, brought forward the idea that citing is an aid to persuasion:

> A scientist who has obtained results which he believes to be true and important has to persuade the scientific community (or, more precisely, certain parts of that community) to share his opinions of the value of his work ... Accordingly, authors typically show how the results of their work represent an advance on previous research; they relate their particular findings to the current literature of their field; and they provide evidence and argument to persuade their audience that their work has not been vitiated by error, that appropriate and adequate techniques and theories have been employed, and that alternative, contradictory hypotheses have been examined and rejected (Gilbert, 1977, pp. 115-116).

Here, in order to support their research findings and to convince readers of their claims to knowledge, scientists tend to cite documents that they assume that their audience will regard as "authoritative" (Moed and Garfield, 2004).

Cozzens (1989) summed up the differences between the normative theory of citing behavior and Gilbert's (1977) assumption that citations serve persuasion of other scientists as follows:

> The main point which emerges is that citations stand at the intersection between two systems: a rhetorical (conceptual, cognitive) system, through which scientists try to persuade each other of their knowledge claims; and a reward (recognition, reputation) system, through which credit for achievements is allocated (Cozzens, 1989, p. 440).

Empirical tests of the validity of the two theoretical approaches were undertaken by Baldi (1998), Collins (1999), Stewart (1983), and White (2004). Baldi (1998) examined

normative versus social constructivist processes in the allocation of citations using a network-analytic model. The results identified significant positive effects of cited article cognitive content and cited article quality on the probability of citations, providing support for a normative interpretation of the allocation of citations in which citations reflect payment of intellectual debt. In contrast, indicators of an author's position within the stratification structure in the world of scholarship failed to significantly improve the fit of the network-analytic model, and thus provided no support for the social constructivist claim that citations are rhetorical tools of persuasion. With regard to the distribution of recognition to scientific articles, Stewart (1983, 1990) reports similar results within geological sciences.

Using transcripts of interviews and conversations with scientists, Collins (1999) examines the reception of published papers in the field of gravitational-radiation research. His results suggest – in agreement with the social constructivist view of citing behavior – that the reception of papers varies with different scientific communities which are receiving them. For example, if scientist credibility has been lost within a scientific community, his claims are largely ignored (see also Collins, 2000). White (2004) examined citation identities for 28 authors (a citation identity is "a list of an author's citees ranked by how frequently that author has cited them in publications" (White, 2004, p. 93)) in several disciplines of science and scholarship and the overall citation counts of citees, which indicate their reputations, showing "that the reputational counts of their citees always have an approximately log-normal distribution: citations to very famous names are roughly balanced by citations to obscure ones, and most citations went to authors of middling reputation" (White, 2004, p. 93) (see also Boyack and Klavans, 2005; Cole, 1970). White (2004) concludes, "the results are better explained by Robert K. Merton's norm of universalism, which holds that citers are rewarding use of relevant intellectual property, than by the constructivists' particularism, which holds that citers are trying to persuade through manipulative rhetoric" (White, 2004, p. 93).

Cronin (2005b) resumes the empirical findings of the studies that tested the validity of the two theoretical approaches as follows: "The weight of empirical evidence seems to suggest that scientists typically cite the works of their peers in a normatively guided manner, and that these signs (citations) perform a mutually intelligible communicative function" (Cronin, 2005b, p. 1508).

2. Empirical results of studies on citing behavior

In recent years a number of empirical studies have been published that offer motivations for, or categories of, citations and their use. In terms of methodology, basically two approaches have been explored:

(1) context or content analyses; and

(2) postal surveys or face-to-face interviews of scientists on the topic of citing behavior.

Most of the studies reviewed here belong to the area of context or content analysis, which seeks to obtain a better understanding of relationships between citing and cited works:

Citation context studies have tried to devise a classification or taxonomy based on a text analysis in order to find out the inter-document relationship in the presence of

reference citations, while content analysis has tried to characterise the cited work by analysing the semantic content of the citing papers (Liu, 1993a, p. 379). In contrast, citer motivation surveys or interviews have tried to identify citer motives by surveying or interviewing the authors themselves.

2.1. Pioneer work on citing behavior

Garfield (1962) published the earliest paper listing possible motivations of citers. Garfield categorized citations on the basis of their observed location in the text, their language content, and their variations, differences, and regularities in patterns of use. The categories of possible citing motives were presented with no statistics on the relative frequencies of occurrence. Garfield's (1962) listed the following reasons for citing, which refer to both the normative theory of citing behavior and the constructive view:

- Paying homage to pioneers.
- Giving credit for related work (homage to peers).
- Identifying methodology, equipment, etc.
- Providing background reading.
- Correcting one's own work.
- Correcting the work of others.
- Criticizing previous work.
- Substantiating claims.
- Alerting to forthcoming work.
- Providing leads to poorly disseminated, poorly indexed, or uncited work.
- Authenticating data and classes of fact (physical constants, etc.).
- Identifying original publications in which an idea or concept was discussed.
- Identifying original publication or other work describing an eponymic concept or term (. . .).
- Disclaiming work or ideas of others (negative claims).
- Disputing priority claims of others (negative homage) (Garfield, 1962, p. 85).

At about the same time as Garfield (1962), Lipetz (1965) published a similar classification scheme for various types of citing behavior. As the two authors did not give frequencies of the occurrence of the postulated types of citing, their contributions were conceptual in nature. But both of their studies triggered a number of subsequent, empirical investigations of citing behavior.

2.2. Context analyses of citations in citing documents

Context analyses of citations in citing, or source, documents sought to illuminate the inter-document relationship implied by the presence of citations by devising a classification or taxonomy based on an analysis of the text surrounding the citations (Cronin, 1984). Context analyses are document based and require that the citing publication must be read to determine the context in which the cited, or target, document was used and the semantic content of the text surrounding the citation. With any substantially cited publication this can be a massive undertaking (McCain and Turner, 1989).

Moravcsik and Murugesan (1975, see also Murugesan and Moravcsik, 1978) provided the first results of a comprehensive citation context analysis (for an analysis of the impact of this study, see Moravcsik, 1988). The authors investigated citations in 30 articles dealing with theoretical high energy physics published in *Physical Review* between 1968 and 1972. The citation categories used by Moravcsik and Murugesan (1975) for classifying citations in *Physical Review* articles are shown in Table I. The first category (conceptual versus operational citations) and the third category (evolutionary versus juxtapositional citations) in Table I are meant to provide insight into the aims and the type of connectedness of scientific communication. In contrast, the second category (organic versus perfunctory citations) and the fourth category (confirmative versus negational citations) are directly related to the quality of citations. The fifth category (valuable versus redundant) refers to the importance of citations for the citing work.

Moravcsik and Murugesan (1975) classified each citation in the 30 articles according to these five pairs of opposite characteristics. The results in Table I show that the majority of the citations could be assigned to the categories valuable (69 percent), organic (60 percent), and evolutionary (59 percent). Only about 14 percent of the citations cited publications that the authors of the articles refer to as wrong or disputed papers. Moravcsik and Murugesan (1975) concluded that the high percentages of valuable, organic, and evolutionary citations, which reflected research impact on the citing works, and the low percentages of citations of the negational type supported the

Citation category	Row percent of cited papers		
	Conceptual	Operational	Neither
Is the citation made in connection with a concept or theory that is used in the citing article (conceptual) or is it made in connection with a tool or physical technique used in the citing article (operational)?	53	43	7
	Organic	Perfunctory	Neither
Is the citation truly needed for the understanding of the citing article (organic) or is it mainly an acknowledgment that some other work in the same general area has been performed (perfunctory)?	60	41	1
	Evolutionary	Juxtapositional	Neither
Is the citing article built on the foundations provided by the cited article (evolutionary) or is it an alternative to it (juxtapositional)?	59	40	2
	Confirmative	Negational	Neither
Is it claimed by the citing article that the content of the cited article is correct (confirmative) or is its correctness disputed (negational)?	87	14	5
	Valuable	Redundant	Neither
Is the citation essential (valuable) or is the citation made to several articles, each of which makes the same points (redundant)?	69	31	–

Notes: Number of source articles = 30; number of citations = 575. Because of multiple uses of cited papers in *Physical Review* articles, the row percents do not always add up exactly to 100 percent
Source: Moravcsik and Murugesan (1975, p. 90)

Table I.
Context analysis of citations in theoretical high energy physics articles

assumptions of the normative theory of citing behavior. But they also concluded that the large fraction (41 percent) of perfunctory references raised serious doubts "about the use of citations as a quality measure, since it is then quite possible for somebody or some group to chalk up high citation counts by simply writing barely publishable papers on fashionable subjects which will then be cited as perfunctory, 'also ran' references" (Moravcsik and Murugesan, 1975, p. 91). In addition, the high number of redundant references (31 percent) was seen to cast doubt on the assumptions of the normative theory and thus the use of citations as an indicator for research impact.

Inspired by the study by Moravcsik and Murugesan (1975), Chubin and Moitra (1975) examined citations in 33 letters published in *Physical Review Letters* and *Physical Letters B* and ten full-length articles published in *Physical Review* and *Nuclear Physics* (all published between 1968 and 1969). Table II shows the categorization devised by Chubin and Moitra (1975), which focuses on classifying citation context as affirmative (four types) or negational (two types). Even though these categories are different than those used by Moravcsik and Murugesan (1975), Chubin and Moitra reached similar results: the citations made by the scientists in letters and full-length articles were most frequently affirmative basic essential (27 percent and 13 percent) or affirmative subsidiary essential (13 percent and 34 percent) citations, and affirmative additional supplementary citations (32 percent) were also made (see Table II). The citations in these categories can be assumed to reflect research impact of the cited on the citing work. About one-fifth of the citations were found to be affirmative perfunctory citations. Chubin and Moitra (1975) found only very low percentages of negational citations (6 percent and 4 percent).

Citation category	Percent of citations: Letters	Percent of citations: Full-length articles
The cited paper is declared central to the reported research; the reported findings depend on the cited paper (basic essential citation)	27	13
The cited paper is not directly connected to the subject of the letter or article, but is still essential to the reported research (subsidiary essential citation)	13	34
The cited paper contains an independent supportive observation (idea or finding) with which the citer agrees (additional supplementary citation)	32	32
The paper is cited without additional comment (perfunctory supplementary citation)	22	17
The citer suggests that the cited paper is erroneous in part and offers a correction (partial negational citation)	6	4
The citer refers to the cited paper as being completely wrong and offers an independent interpretation of solution (total negational citation)	–	–
Total	100	100

Notes: Number of source papers = 43 (33 letters, ten full-length articles); number of citations = 443 (letters = 265, full-length articles = 178)
Source: Chubin and Moitra (1975, p. 429)

Table II.
Context analysis of citations in theoretical high energy physics letters and full-length articles

As the next step in their analysis, Chubin and Moitra (1975) investigated the course of citation of a selection of papers that were cited in the theoretical high energy physics papers in the form of affirmative essential (basic or subsidiary essential) or partial negational citations. For works that had been cited in the form of partial negational citations, it was noteworthy that they were highly cited immediately after publication, and then there was a rapid rate of decay (decline in citations to these sources). Papers that had been cited in the form of affirmative essential citations did not show that kind of course.

Spiegel-Rösing (1977) conducted the first citation context analysis outside of the field of physics. Spiegel-Rösing analyzed citations in 66 articles published in the journal *Science Studies* between 1971 and 1974 (volume 1-4). Table III shows the results of Spiegel-Rösing's context analysis of a total of 2,309 citations. By far the most frequent kind of use of cited research in *Science Studies* (80 percent) was to substantiate a statement or an assumption made in the citing text or to point out further relevant information. The remaining 20 percent of the citations could be assigned to 12 other citing categories: for example, 6 percent of all citations were used to acknowledge previous research in the same area; 5 percent were used for comparative purposes. In agreement with the two studies described just above, Spiegel-Rösing (1977) found a very low incidence of critical citations (2 percent).

Frost (1979, 1989) reported the results of two citation context analyses. In 1979 Frost proposed a scheme for the classification of citations and applied it to a sample of publications within German literary research. The results of this study show that the

Citation category	Percent of citations
Cited source substantiates a statement or assumption, or points to further information	80
Cited source is mentioned in the introduction or discussion as part of the history and state of the art of the research question under investigation	6
Cited source contains the data (pertaining to the discipline of the citing article) which are used for comparative purposes, in tables and statistics	5
Cited source contains the data (pertaining to the discipline of the citing article) which are used sporadically in the citing text	2
Cited source is positively evaluated	2
Cited source contains the method used	1
Cited source contains the concepts, definitions, interpretations used (and pertaining to the discipline of the citing article)	1
Cited source is the specific point of departure for the research question investigated	1
Results of citing article disprove, put into question the data as interpretation of cited source	1
Cited source is negatively evaluated	1
Results of citing article prove, verify, substantiate the data or interpretation of cited source	0
Results of citing article furnish a new interpretation/explanation of the data of the cited source	0
Cited source contains data and material (from other disciplines than citing article) which are used sporadically in the citing text, in tables or statistics	0
Total	100

Notes: Number of source articles = 66; number of citations = 2,309
Source: Spiegel-Rösing (1977, p. 105)

Table III.
Context analysis of citations in *Science Studies* articles

work of other scientists was used more often for the positive purposes of supporting the work of the citing scientist or referring the reader to additional reading than it was used to supply an object for rebuttal (Frost, 1979). Citations to previous work of scientists for the purpose of disagreeing with an opinion or factual statement and to express mixed opinions were less frequent. Ten years later, Frost (1989) conducted a context analysis with 828 citations in 74 articles published between 1980 and 1985 dealing with online public access catalogues. The most frequent use of citations (32 percent) was to refer to research methodologies or findings. In contrast, comparison of the findings with the citing author's own research (self-citation) or citing the findings in order to substantiate the argument of the citing scientist (citing as persuasion) was much less frequent (Frost, 1989).

Krampen and Montada (2002) conducted a citation context analysis with a stratified random sample of 90 articles published in international scientific psychological journals. Each citation ($n = 5,958$) in the articles was classified as a certain type according to a category system. Krampen and Montada found (see Table IV) that almost 60 percent of all citations were related directly and substantially to the results (30 percent), theories or concepts (20 percent), and methods (9 percent) in the cited document. Critical (negative) citations (1 percent) in the articles published in international scientific psychological journals were very rare. According to Krampen and Montada (2002) these findings confirm the normative theory of citing, even though it was also the case that almost one-third of all the citations were just mentions of other works (5 percent) or perfunctory references to works providing an overview (25 percent) (see Table IV).

2.3. Content analyses of citations to characterize the cited works

Whereas studies described in section 2.2 scrutinized the context of citations in citing documents, the studies described in this section analyzed the semantic content of the citing passage for the purpose of characterizing the cited works. Cole (1975) conducted an early study for a festschrift in honor of Robert K. Merton (see section 1), analyzing

Citation category	Percent of citations
Direct reference to an empirical finding in the cited document	30
Simple mention (of the type "compare here also," "see also," "see, for example") without any further more specific reference to the cited document	25
Direct reference to a theory or concept in the cited document	20
Direct reference to a method in the cited document	9
Overview citation (of the type "for an overview, see here," "see summary in") without any further reference to the cited document	5
Use of a data collection method (such as a test) taken from the cited document	3
Word-for-word quotation of text in the cited document	3
Use of a statistical method taken from the cited document	2
Substantial, theoretical, or methodological critique of the cited document	1
Use of a table, figure, or list taken from the cited document	0
Other citation type (for unclear citations)	2
Total	100

Notes: Number of source articles = 90; number of citations = 5,958
Source: Krampen and Montada (2002, p. 69, freely translated here)

Table IV.
Context analysis of citations in articles published in scientific psychological journals

123 articles that had cited Merton. Cole was interested in discovering the importance that Merton had achieved in the scientific community at the time. Cole's analysis shows that about half of the articles had cited Merton's work in a "ceremonial" fashion: "In fact, it is the theoretician as an authority that is being utilized rather than substantive theory" (Cole, 1975, p. 208).

Whereas Cole's (1975) study was a bibliometric investigation of the standing of a scientist, two other studies (Garfield, 1978; Garfield and Welljamsdorof, 1990) tested the influence of critical attitudes of scholars on the allocation of citations. Garfield (1978) did a content citation analysis of citations to a highly debated article by Arthur Jensen published in *Harvard Educational Review*. According to Garfield (1978), Jensen's (1969) article had been so frequently cited because it was seriously criticized: Of the 60 papers, more than half had cited Jensen's (1969) article negatively or as an example of a controversy. Eight articles had used it as a background reference; only 15 articles cited Jensen in agreement with Jensen's positions. Garfield (1978) speculated that scientists probably felt they could not disregard Jensen's work: "Contemporary scientists must classify it as important but questionable science. Since most high impact science proves to be great science, the Jensen case is an exception that illustrates one must be cautious in using citation data" (Garfield, 1978, p. 14). In a later study, Garfield and Welljamsdorof (1990) investigated the impact of falsified studies on research by investigating citations to such works and how citing authors used them. Garfield and Welljamsdorof (1990) focused on 20 publications "by Steven E. Breuning, who in 1988 was prosecuted and convicted in federal court of scientific fraud" (Garfield and Welljamsdorof, 1990, p. 90, see also Anderson, 1988, Holden, 1987). Garfield and Welljamsdorof (1990) performed a citation content analysis of 65 articles in which Breuning's work is cited. Their findings indicate that less than 10 percent of the citations were positive in nature. Somewhat different results arise from a study of Kochan and Budd (1992). In this study citations in 298 papers were content analyzed that refer to articles of John Darsee. "Darsee was discovered to have fabricated the data which formed the bases for many articles and abstracts he published" (Kochan and Budd, 1992, p. 488). Despite the publicity his case received in biomedical science, Darsee's articles are cited predominant positively in subsequent papers.

For the first part of a large citation content analysis, Oppenheim and Renn (1978) selected 23 "highly-cited old papers" in the subject fields of physics and physical chemistry and content analyzed a set of 978 randomly selected papers that cite them between 1974 and 1975. The results of the citation content analyses in Table V (column 2) show that 39 percent of the citations were made for the purpose of providing historical background. About one-fifth of the citing articles cited one of the 23 in order to describe other relevant work; 16 percent used methodology from the cited work and 11 percent used theoretical equations. In 1 percent of the citing articles, the cited paper was mentioned in order to state that its theory or method was not applicable or not the best one to use for present purposes or the cited paper was criticized.

In the second part of this large citation context analysis, Oppenheim and his team examined a semi-random sample of 100 articles (of a total of 2,061 articles) that cited the highly-cited paper by Watson and Crick (1953) announcing the discovery of the structure of DNA (Ahmed *et al.*, 2004). Again, the reasons for citing this paper were categorized. The results of the second study in Table V (column 3) show that 85 percent of the articles cited Watson and Crick (1953) for historical reasons or background

Citation category	Percent of citations First study	Second study
Historical background (e.g. the author of the cited paper was the first person to work in the field; giving credit for related work and providing background reading)	39	48
Description of other relevant work (e.g. a paper gives some relevant information; a paper makes a statement with which the citing author agrees)	19	37
Use of theoretical equation (i.e. the paper actually employed the theoretical equation cited for calculation purposes)	16	4
Supplying information or data for comparison (i.e. a citing author made use of a cited article to obtain information that was used for comparison)	13	0
Use of methodology (i.e. a citing author made use of a practical or theoretical technique given in the cited paper)	11	5
A citing author felt it was necessary to state that a certain theory or method was not applicable or not the best one to use for his purpose. A citing author criticized the cited paper	1	2
Supplying information or data, other than for comparison (i.e. a citing author made specific use of information or data contained in a cited paper)	1	4
Total	100	100

Notes: First study: Oppenheim and Renn (1978). Number of source papers = 23; number of citing papers = 978. As some highly cited papers were cited several times in a citing paper, a total of 1,106 citations were classified. Second study: Ahmed *et al.* (2004, p. 154). Number of source papers = 1; number of citing papers = 98. As two articles cited the Watson and Crick (1953) twice, a total of 100 citations were classified

Table V.
Content analysis of citations in the fields of physics and physical chemistry (first study) and to Watson and Crick's (1953) article (second study; in percent, sorted by percent of citations in the first study column)

discussion (compared to 58 percent in the first study). Ahmed *et al.* (2004) found only two articles (2 percent) criticizing Watson and Crick's (1953) work. Whereas in the second study only 13 percent of the sample were actively using Watson and Crick's (1953) information (4 percent), methods (5 percent), or theory (4 percent), a greater proportion (28 percent) of the citations in the first study were made for this purpose (information=1 percent, methods=11 percent, theory=16 percent). This clear difference is astonishing, as Watson and Crick won the Nobel Prize in Physiology or Medicine in 1962 for their research results published in the 1953 article.

Hooten (1991) widened the Oppenheim team's research approach and examined the nature of use of not only frequently but also infrequently cited papers (published in the *Journal of the American Society for Information Science* in 1972, 1973, and 1974) by the authors who cited them. Hooten (1991) was interested in whether papers in both groups are used differently by the citing scientists. The sample consisted of 148 papers citing infrequently cited papers and 170 papers citing frequently cited papers. Frequently-cited papers were more likely to be repeatedly mentioned in the papers in which they were used than infrequently-cited papers. In addition, the findings of Hooten's (1991) citation content analysis show (as expected) that infrequently-cited articles were less central than frequently-cited articles to the author's message.

Maricic *et al.* (1998) conducted an analysis of citations using both the location of the citations to 357 papers produced by a multidisciplinary institute in different sections of the citing articles (introduction, methods, results, and discussion) and the citing level for each citation. Maricic *et al.* (1998) recorded the level of citing as high or low according to a

simple distinction: meaningful or high intensity citing level (the essential, central, or organic citing type) of the cited paper versus cursory or low intensity citing level (in other words, the nonessential, peripheral, or perfunctory citing type). The results show that cursory or low intensity citations were dominant in the introduction section of papers and meaningful or high intensity citations were dominant in methods, results, and discussion sections. As the most important result, the study showed in a further step "that no congruency was found between, on the one hand, a purely numerical citation analysis, taking the citation events at their face value, and, on the other hand, context analysis based on the citing taxonomy (high/low intensity levels) and citing location (within the citing papers)" (Maricic *et al.*, 1998, p. 538). Thus, the results could not support the current practice of evaluating scientific achievements by means of statistical analysis of citation frequency counts without additional information.

Hanney *et al.* (2003) examined the impact of papers of the first generation of diabetes and cardiology research ($n = 29$) on papers of the second generation published some years later ($n = 623$) through citation content analysis (Hanney *et al.*, 2003, see also Hanney *et al.*, 2005a). To examine the strength of impact Hanney *et al.* (2005b) used a classification scheme based on Cano (1989): 35 percent of the citations in the second generation of diabetes and cardiology research papers to the first generation papers were categorized as only of peripheral importance, 56 percent as limited, 8 percent as considerable, and only 1 percent as essential (see Table VI). Further analyses showed that the number of times a paper is cited can not be used to indicate the importance of that paper to the articles that cite it. Altogether, the results suggest that in the area of diabetes and cardiology research, early research is highly important in only a small minority of papers of the later generation (9 percent).

2.4. Citer motivation surveys or interviews

In addition to citation context or content analysis, an important approach in the investigation of citing behavior is direct survey or interviewing of scientists, as the intentions of the citing scientists are not normally available to content analysts (Gilbert, 1977). Several studies have used this citer-oriented approach and have

Citation category	Percent of citations
Limited. The work described in the cited article is of some limited importance to the citing article. It would be inappropriate to omit it, but it is not an important part of a central argument	56
Peripheral. The work described in the cited article is of little importance to the citing article. Citation is simply background, an aside, for completeness or indeed irrelevant	35
Considerable. The work described in the article is of considerable importance to the citing article. The work is one of a number central to the argument	8
Essential. The work described in the cited article is of critical importance to the citing article, and central to the argument presented, and a key foundation for the paper	1
Total	100

Notes: Number of source papers = 29; number of citing papers = 623
Source: Hanney *et al.* (2005b)

Table VI.
Content analysis of citations to first generation diabetes and cardiology papers

generally provided citing authors with a checklist of possible motivations for citing. Brooks (1985, 1986) was the first researcher to ask scholars systematically and directly to state their particular motivations for specific citations. Brooks interviewed 20 authors of recently published academic articles representing a wide spectrum of university departments (e.g., anatomy, computer science, and education) about their citation motives. Brooks (1985, 1986) classified the citer motivations named by the authors as belonging to three groups:

(1) persuasiveness, positive credit, currency, and social consensus;

(2) negative credit; and

(3) reader alert and operational information.

The data showed that persuasiveness had achieved remarkable success as a citing motivation. Brooks (1985, p. 227) points out that "authors can be pictured as intellectual partisans of their own opinions, scouring the literature for justification".

At about the same time as Brooks (1985, 1986) Vinkler (1987) surveyed 20 authors of articles on chemistry at the Central Research Institute for Chemistry (CRIC, now Chemical Research Center, Budapest, Hungary) on their citing motivations. The scientists were asked to assess their motivations for a total of 484 citations in their articles (20 articles) according to predefined categories. Vinkler (1987) categorized the motivations into two major groups (see Table VII):

Citing motivation	Percent of citations
Professional motivations. The particular paper was cited because ...	
– in my paper a review of literature is given due to "completeness", "preliminaries"	51
– a minor part of the cited work (application of part of a methodology) is utilized	42
– the cited work confirms, supports the results in the citing paper	16
– a significant part of the cited work (theory, measuring methods) is utilized	15
– my work is based entirely on the cited work	4
– the cited work is criticised in some minor point	3
– the cited work is refused, criticised in one important question	2
– the cited work is fully refused, criticised	0
Connectional motivations. The particular paper was cited because ...	
– the paper is my own, and I want to make publicity to it by citing	37
– honour, respect toward the authors caused me to cite the work	17
– professional connection is maintained with the cited author or I wish to build it	15
– the cited paper was written by widely known, respected authors	12
– I want to make publicity to the cited paper in this way	8
– the cited paper was written by persons on whom I depend in some way	6
– the cited paper was published in an important (respected) journal	6
– the paper was cited by others, too	5
– I expect professional or private benefit from citing	4
– I needed more references (citation was, in fact, unnecessary)	0

Notes: Number of source articles = 20; number of citations = 484. As the survey participants could assign their citations to more than one citing motivation category, the sum of the percentages in the Table is greater than 100 percent
Source: Vinkler (1987)

Table VII.
Citing motivations in the field of chemistry

(1) professional motivations, related to theoretical and practical content of the cited work; and

(2) connectional citing behavior, motivated by the wish to build social relationships in the scientific community.

Within the professional citing motivations, the results in Table VII show that the documentary reason for citations (due to "completeness") was the most frequent citer motivation of the authors (51 percent). Works were also cited frequently (42 percent) in order to acknowledge the part of the cited work that was utilized for the author's own work. Citations for the purpose of criticizing a work played a relatively inferior role, amounting only to a small percentage of all citations (all in all 5 percent). Within the connectional citing motivations, Table VII shows that with the exception of giving credit to one's own work (37 percent), these motivations played a much smaller role in citing behavior than professional citing motivations. Vinkler (1987) concluded from the results overall that citations were influenced primarily by professional motivations and were therefore reliable for scientometric purposes.

Cano (1989) followed the model developed by Moravcsik and Murugesan (1975, see above) to test the model's citing behavior definitions empirically. Our literature search revealed that Cano's study (1989) was one of few citing behavior studies that attempted to replicate findings empirically. Cano asked a group of scientists working in the field of structural engineering ($n = 42$) to classify the citations ($n = 344$) that they had made in two of their recent papers according to the citing behavior definitions proposed by Moravcsik and Murugesan (1975). The results in Table VIII show that the major citation category used by the scientists was perfunctory (26 percent). While the scientists also judged their citations as organic (21 percent) and conceptual (19 percent) comparatively frequently, the proportion of negational citations was very low

Citing motivation category	Percent of citations
Perfunctory. The citation is mainly an acknowledgment that some other work in the same general area has been performed	26
Organic. The citation is truly needed for the understanding of the citing article	21
Conceptual. The citation is made in connection with a concept or theory that is used in the citing article	19
Operational. The citation is made in connection with a tool or technique used in the citing article	12
Evolutionary. The citing article built on the foundations provided by the cited article	14
Juxtapositional. The citing article is an alternative to the cited article	4
Confirmative. The citing article claimed that the content of the cited article is correct	2
Negational. The citing article disputed the correctness of the cited article	2
Total	100

Notes: Number of source papers = 84; number of citations = 344. Participants could assign their citations to more than one category; there were thus a total of 473 assignments
Source: Cano (1989, p. 285)

Table VIII.
Citing motivation categories used in the field of structural engineering

(2 percent). Examining also the locations of the citations in the papers (introduction, methods, results, and discussion) Cano found that perfunctionary citations were primarily located in introductory sections: "This result might lead to the hypothesis that citations located at introductory sections of technical papers represent a mere 'setting of the stage' and have very little informational utility to the authors of the papers" (Cano, 1989, p. 288).

In a survey by Bonzi and Snyder (1991) of 51 authors, all faculty members of the State University of New York College (NY, USA) and Syracuse University (NY, USA), the authors were asked why they chose to cite both themselves and others. The results show that "there are no significant differences in the motivations for citing between self-citations and citations to other works" (Snyder and Bonzi, 1998, p. 431). Not long after Bonzi and Snyder's (1991) survey, Liu (1993b, p. 15) surveyed 415 scientists who published articles in Chinese Physics between 1981 und 1987. Each scientist was asked to state the proportion of cited works that he or she considered to be essential to his or her research. The results show "that only a minority of scientists said that more than 80% of their citations were essential. A few even stated their citations were totally non-essential. Others said that their reference citations were moderately essential. The data give an indication that, more often than not, the cited documents were used in a more peripheral than critical manner. The lesser essentiality of the citation gives the notion that necessity or importance of a reference is not the only reason a scientific author cites a reference" (Liu, 1993b, p. 21).

Shadish *et al.* (1995) conducted two surveys that sampled several hundred citations from papers in psychology journals and surveyed the authors of these papers about their motivations for citing. The questionnaire contained about 30 items reflecting motivations for citing. Shadish *et al.* (1995) computed a factor analysis of the responses to examine patterns among the items and extracted the following six factors:

(1) *exemplar citations* (e.g., a classic reference in the field, authored by a recognized author);

(2) *negative citations* (e.g., contradict a perspective or finding);

(3) *supportive citations*;

(4) *creative citations* (e.g., the method or theoretical perspective is unusual or innovative);

(5) *personally influential citations* (e.g. major source of an idea); and

(6) *citations made for social reasons* (e.g., authored by someone who might have been influential in the review process; published in an prestigious journal in the field).

Shadish *et al.* (1995) then tested the relationship between citing authors' perceptions of citations (the six factors) and citation frequencies – how often the cited works are cited by other scientists. They were interested in determining which of the groups of factors was associated with highly-cited papers. The result of a multiple regression analysis shows that highly-cited papers are perceived by citers as exemplars (factor 1) and as less creative (factor 4). The surprising and somewhat counter-intuitive lower creativity of highly-cited papers was interpreted by Shadish *et al.* (1995, pp. 484-485) as follows:

> On the one hand, creativity may be a reason that some articles are perceived as being exemplars and of high quality, which in turn increases citation counts. But once one accounts for this, another part or creativity seems to result in works not being cited as much. These might, for example, be those articles that are creative in a way that does not fit into existing conceptual frameworks or into accepted social norms for scholarship in an area. Such works might not be cited much even though they are acknowledged to be creative. Or they may be so creative that they rapidly become part of the accepted canon, and henceforward are rarely specifically cited.

In a similar study, Case and Higgins (2000) also examined motivations for citing highly-cited papers. Case and Higgins identified the works of two highly-cited scientists in the discipline of communication studies. All of the authors who cited them ($n = 55$) between 1995 and 1997 were asked why they had cited the works. In their analysis of citer motivations, Case and Higgins distinguished between citations to the most highly-cited documents published by the two scientists and citations to their less-cited works.

Table IX shows Case and Higgins' (2000) results. The highest-ranked items reflecting the most important motivations for citing both less-cited und highly-cited documents were "this cited work reviews prior work in this area" (24 percent) and "this cited work is a 'concept marker'" (20 percent). Case and Higgins found great differences in the proportions of citing motivations for less-cited and highly-cited documents for three citing motives. While less-cited documents are cited more frequently than highly-cited documents (18 percent versus 4 percent) to establish the legitimacy of the citer's topic, highly-cited documents are more frequently cited than less-cited

Most important motivation	Percent of citations … … to less-cited documents ($n = 28$)	… to highly-cited documents ($n = 27$)	… to both ($n = 55$)
The cited work reviews prior work in this area	14	33	24
The cited work is a "concept marker" – it represents a genre of studies, or a particular concept in the field	18	22	20
The cited work documents the source of a method or design feature	11	11	11
The cited work helps establish the legitimacy of the topic of your article	18	4	11
The cited work is authored by a recognized authority in the field	0	11	5
Other motivations (in total, 12 further motives were mentioned by only one or two of the survey participants)	39	19	29
Total	100	100	100

Notes: Number of citations = 55 (28 citations to less-cited documents and 27 citations to highly-cited documents)
Source: Case and Higgins (2000, p. 640)

Table IX.
Most important motivations of authors for citing less-cited and highly-cited documents published by two highly-cited scientists

documents (33 percent versus 14 percent) in order to review prior work in the area. Only highly-cited documents (11 percent) are cited because the cited work is authored by a recognized authority in the field.

The results of a multivariate analysis including citation counts as dependent variable and motivations for citing as independent variables revealed three significant factors in predicting citation counts: first, the perception that the cited work is novel, well known, and represents a genre of studies; second, the judgment of the citing scientist that citing a prestigious work will promote the cognitive authority of his or her own work; and third, the perception that a cited item serves criticism – which could also serve to establish the citer as an authoritative, critical thinker (Case and Higgins, 2000).

2.5. Studies on the motivations of scientists for non-citing

The studies on citing behavior presented thus far examined only motivations for citing, not motivations resulting in not citing documents. There may be a number of motivations why a citing scientist has not provided a link to certain other documents. In a first study on the decision to cite and not to cite certain documents, Cronin (1981b) investigated the extent to which authors may differ in their opinions on the necessity to cite. Cronin secured an unpublished paper on the subject of school phobia and removed all accompanying citations. A total of 19 psychologists in the UK marked their copies of the paper with an asterisk at those points where they felt a citation was called for. The results showed that there was a considerable lack of unanimity between the author of the unpublished paper and the psychologists as regards the ideal number and positioning of citations within the experimental paper.

A few years later MacRoberts and MacRoberts (1986, 1988, 1997, 1987, 1989b) conducted a number of studies on whether scientists in the history of genetics in fact cite those works that have influenced their own work. For example, MacRoberts and MacRoberts examined articles to find out how specific facts that originated with particular individuals in particular papers were credited by subsequent authors (MacRoberts and MacRoberts, 1987). They selected 13 facts and traced them through 23 articles and noted three patterns:

(1) some work was used but was either never cited or cited rarely;

(2) some work was cited mainly or only through secondary sources; and

(3) some work was credited every time it was used.

Neither this study nor similar studies conducted by MacRoberts and MacRoberts (1986, 1988, 1997) support the basic assumption of evaluative bibliometrics that scientists really cite their intellectual or cognitive influences. Instead, the results of the studies gave support to the general finding that giving credit to the work of colleagues was not a primary motive for citing.

White and Wang (1997) conducted a long-term study of decision-making regarding use and non-use of documents by 12 agricultural economists when writing their own publications. Structured interviews were conducted with each study participant. First of all, the content analysis of the interviews shows, in agreement with MacRoberts and MacRoberts' (1987) findings, that the interviewees cited fewer documents than they had read during their research process. Furthermore, in the interviews White and Wang (1997) identified a number of motivations of the study participants for citing and

for not citing. Table X shows the number of decisions to cite and not cite a document, broken down by different motivations.

As Table X indicates, four out of five motivations ("topicality," "content," "orientation," and "relation") were apparent in both positive and negative decisions (that is, to cite and not to cite). The most frequently named motives for citing or not citing ("topicality" and "content") indicated that the author's judgment as to the contribution the cited document made to the author's research played the most important role in the decision to cite or not cite. A clear difference was revealed between decisions to cite and not cite with regard to classic works in the field (see Table X, "Classic/Founder"). In making a negative decision the participants did not comment on the recognition of a document in the field as the first substantial work on a topic or technique.

Kurtz *et al.* (2005) examined scientists' decisions to cite or not to cite by using the usage logs of the NASA Astrophysics Data System (the digital library that astronomers now use to access the literature in their fields). Kurtz *et al.* compared the obsolescence function as measured by actual "reads" of individual articles in the digital library with the obsolescence function as measured by citations of those articles. The statistical results of the comparison show that "reads" of articles and "cites" of articles measure the same thing, namely, the usefulness of an article for scientists.

3. Discussion

Evaluative bibliometric studies are based on the assumption that using professional literature in a field and citing it in publications reflects the obligation to acknowledge

Motivation	Decision not to cite (%)	Decision to cite (%)
Topicality. What the document is about as the interviewee sees it with respect to his tasks at hand. Whether or not the topic of a document is related to the topic of the interviewee's project	54	35
Content. The nature of the materials included in the interviewee's project, e.g. data, methodology, and theory, as noted	13	23
Orientation. At which intellectual level the document is written and for which audience it is intended	5	5
Relation. Recognition of an author or an organization brings in a relationship between the user and the source of the document. The document becomes useful to this particular user because of his/her particular situation or position	3	5
Classic/Founder. The document is recognized in the field as the first substantial work on a topic or technique	0	9
Other motivations (the study participants named a total of 22 further motives)	25	23
Total	100	100

Notes: Number of interviewees with citing decisions = 12; number of decisions not to cite = 176; number of decisions to cite = 413
Source: White and Wang (1997, p. 137)

Table X.
Motivations of decisions to cite or not to cite certain documents (in percent; sorted by the column "decision not to cite")

reception of others' work. Scientists fulfill this requirement of scientific documentation if "they give credit where credit is due" (American Psychological Association, 2004, p. 349) by indicating the sections of text in their published documents that have been influenced by reception of other publications (see, for example, Deutsche Forschungsgemeinschaft, 1998). In a survey of psychology journal editors and editorial advisory board members (Cronin, 1982), more than 80 percent of the participants believed that scientists frequently fail to cite all pertinent work and that authors tend to cite those whose views support their own. The citing behavior of scientists also includes manipulated citing strategies that reflect an effort to mention the works of respected persons and to deliberately apply "citation machinery," i.e. to include citations with the aim of calling the attention or gaining the favor of editors, referees, or colleagues (Vinkler, 1987).

As mentioned above, two competing theories of citing behavior were developed in past decades: the normative theory of citing behavior and the social constructive approach to citing behavior. Following normative theory, the reasons why scientists cite documents are that the documents are relevant to their topic and provide useful background for their research and in order to acknowledge intellectual debt. The social constructive view on citing behavior contradicts these assumptions. In this view, citations are a social psychological process, not free of personal bias or social pressures and probably not made for the same reasons. Different motivations for citing behavior are to be expected depending on the intellectual and practical environment. Gilbert (1977), who has been particularly associated with the social constructive view, see citations as an aid to persuasion, that is, scientists prefer to cite documents that are supportive of what they write, preferably by noted experts. While Cronin (1984) finds the existence of two competing theories of citing behavior hardly surprising, as the construction of scientific theory is generally characterized by ambivalence, for Liu (1997) and Weingart (2005) the long-term oversimplification of thinking in terms of two theories reflects the absence of one satisfactory and accepted theory on which the better informed use of citation indicators could be based. Whereas Liu (1997) and Nicolaisen (2003) see the dynamic linkage of both theories as a necessary step in the quest for a satisfactory theory of citation, Garfield (1998, p. 70) states: "There is no way to predict whether a particular citation (use of a reference by a new author) will be 'relevant '".

In section 1 we described the results of four studies that investigated empirically the validity of both theoretical approaches. In agreement with the constructive view of citing behavior the results of Collins (1999) suggest that political and economic forces within the research process led to some papers being ignored by scientists, while some were picked out. In contrast, the studies undertaken by Baldi (1998), Stewart (1983), and White (2004) provide more support for a normative interpretation of the allocation of citations than for a social constructivist interpretation. In recent years the implications of the study published by Baldi (1998) were extensively discussed in the literature. Cronin (2004, p. 44) assesses the study as "an important and methodologically rigorous study". Borgman and Furner (2002) consider further comparison of citing behavior within different disciplines necessary if we are to determine how far the results of Baldi (1998) may be generalized. Likewise, Small (1998) could not be completely convinced by the results of Baldi (1998, p. 143) and

states that "a direct empirical test of the two theories seems difficult, and we need to take a step back and view these two theories in a broader context".

Small (2004) recently proposed a first conceptual approach for a unified theory. For Small (2004), the empirical heart of a unified theory are the citation classification schemes that were developed in the studies of citing behavior (see section 2). A possible theoretical framework would be to include all citation categories in what Small calls the "citation cube," considering the dimensions of literalness versus consensus. On the vertical axis of this cube "literalness" would indicate the congruence of the cited work and the citing context from low to high. The horizontal axis labeled "consensus" would indicate the degree of agreement in the citing community on the content of the cited work (Small, 2004, p. 76). Normatively compliant citations, such as affirmational or conceptual citations, would concentrate in the high literal, high consensus box, while deviant cases, such as a revolutionary negative citation or paradigm breaking reinterpretation, would fall mainly into the low literal, low consensus region. In general, Merton's (1973) normative model would work best for high literal citations, while the constructivist model would work best for low literal citations (Small, 2004, p. 77).

In section 2 of this review, we presented a number of empirical studies that, using context and content citation analysis as well as postal surveys and face-to-face interviews, investigated citing behavior mostly under consideration of both theoretical orientations (normative and social constructive). The general trend of the findings is that in addition to acknowledging intellectual and cognitive debts to colleagues, there are a number of other factors that can determine citing behavior. Following Garzone and Mercer's (2000) scheme for classifying citations according to function, we attempt in the following to summarize the most important types of citation in the individual citation analysis studies within a unified typology:

- Citations of the *affirmational* type (citing work confirms cited work; citing work is supported by cited work; citing work depends on cited work; citing work agrees with ideas or findings of cited work; citing work is strongly influenced by cited work). In the citing behavior studies, the percentages for this type of citations range from about 10 percent to 90 percent.
- Citations of the *assumptive* type (citing work refers to assumed knowledge that is general/specific background; citing work refers to assumed knowledge in an historical account; citing work acknowledges cited work pioneers). In the citing behavior studies, the percentages for this type of citations range from about 5 percent to 50 percent.
- Citations of the *conceptual* type (use of definitions, concepts, or theories of cited work). In the citing behavior studies, the percentages for this type of citations range from about 1 percent to 50 percent.
- Citations of the *contrastive* type (citing work contrasts between the current work and cited work; citing work contrasts other works with each other; citing work is an alternative to cited work). In the citing behavior studies, the percentages for this type of citations range from about 5 percent to 40 percent.
- Citations of the *methodological* type (use of materials, equipment, practical techniques, or tools of cited work; use of analysis methods, procedures, and design of cited work). In the citing behavior studies, the percentages for this type of citations range from about 5 percent to 45 percent.

- Citations of the *negational* type (citing work disputes some aspects of cited work; citing work corrects/questions cited work; citing work negatively evaluates cited work). In the citing behavior studies, the percentages for this type of citations range from about 1 percent to 15 percent.
- Citations of the *perfunctory* type (citing work makes a perfunctory reference to cited work; cited work is cited without additional comment; citing work makes a redundant reference to cited work; cited work is not apparently strictly relevant to the author's immediate concerns). In the citing behavior studies, the percentages for this type of citations range from about 10 percent to 50 percent.
- Citations of the *persuasive* type (cited work is cited in a "ceremonial fashion"; the cited work is authored by a recognized authority in the field). In the citing behavior studies, the percentages for this type of citations range from about 5 percent to 40 percent.

The comparatively frequent occurrence of citations of the perfunctory (up to 50 percent), persuasive (up to 40 percent), and the negational types (up to 15 percent) in some of the studies have led a number of scientists to doubt that citations can reflect the intellectual and cognitive impact of research as is assumed by the normative theory of citation. Cano (1989) states that the notions of discreteness and equality of value of citations need to be revised for adequate models of citing behavior to evolve. The strong influence of factors that promote some degree of legitimacy and authority to the citing author through association with the cited work would provide support to Gilbert's (1977) theory that citations are largely used to persuade. Based on the empirical findings Kochen (1978) suggested a modification of the previously used quality indicators and recommended, for example, the use of citation counts in combination with content analysis.

However, the methodological approaches of the studies of citing behavior have been much criticized and the validity of the findings called into strong doubt. One of the most important points of the criticism has to do with the wide differences among the citation studies (Liu, 1993a), which results in the widespread range of the percentages found in the various studies for the different categories of citing behavior. In some studies, each cited work was classified only once, while in other studies a cited work was classified numerous times if it was cited a number of times in an article. In some studies each citation was assigned to only one category, while in other studies a citation could be assigned to several categories. Finally, the studies examined citation behavior in different academic disciplines (such as literary studies, physics, psychology, or science research) and in different types of publications (such as research articles, letters, highly cited or infrequently cited papers). By and large, the development of citation classification schemes has not been a cumulative endeavor. Each classifier has regarded his or her problem or approach as unique (Small, 1982).

The results of the studies on citing behavior were based on either document analysis or surveys of scientists. Document analyses require experts who read and categorize the whole sentences incorporating citations (Maricic *et al.*, 1998). In that case the experts doing their own analysis of why a citation was made in someone else's article, i.e. are guessing at the original author's motivations using their own subjective judgements. This necessarily is a weakness of such an approach. However, document analyses have the advantage of convenience and consistency. The surveys undertaken

to examine citing behavior seek to uncover true citing motives by asking the scientists directly involved in the citing process, instead of imposing too much of a citation analyst's personal judgment. But, in many cases questioning an author cannot reveal the true reasons, because the reasons for citing a particular source and not citing another are very often partly unconscious or neglected by the author (see Hjorland, 2000). Furthermore, it is difficult to get authors to co-operate with such surveys, their memory may be at fault, they will be inconsistent in their understanding of the typology of reasons presented to them and may indeed deliberately mislead regarding their motivations. To date there has been no attempt to join the two perspectives (document analysis and surveys of scientists) to make results more reliable (Hemlin, 1996). "Ideally, an analyst would not only have to examine all citations in context but discuss each with the author, a procedure that has yet to be undertaken in any study that uses citations as data" (MacRoberts and MacRoberts, 1989a, p. 345). The best time for discussion with the author on his or her reasons is the writing phase of the paper. This analysis procedure is likely to result in a more honest set of reasons, but it will be difficult to undertake it[6].

Points of criticism have been not only methodological weaknesses, the lack of replication of studies, and the resulting insufficient reliability of the findings, but also unsatisfactory interpretation of the findings on citing behavior. Citations of the negational type could not be viewed as less valuable *per se* than citations of the affirmational type (Hicks and Potter, 1991). Any citation was seen as better than no citation at all (Baldi, 1998). Just as positive citations could not infallibly indicate goodness, negative citations could not guarantee that something was wrong or bad (White, 2001). Cole and Cole (1971) conclude:

> It is unlikely, however, that work of little value will be deemed significant enough to merit extensive criticism. If a paper presents an error that is important enough to elicit frequent criticism, the paper, though erroneous, is probably a significant contribution ... Let us say that one paper actually receives as many as twenty-five "critical" citations. We suggest that these few pieces of research that stimulate wide criticism have, in fact, stimulated other research. Consequently, it must be considered mistaken but significant; it must be seen as work which has had an impact on future scientific research (Cole and Cole, 1971, p. 25).

Brooks (1985) and Liu (1993a) believe that it is possible that the high proportion of citations of the perfunctory type in some studies (e.g. Chubin and Moitra, 1975; Moravcsik and Murugesan, 1975) has to do with authors' motives being unclear to the content analyst. As Peritz (1983, p. 303) noted, "a practical method of 'labelling' citation for retrieval purposes has not yet been found; the assessment of quality and context, let alone underlying motives, involves a large degree of personal judgement as well as an in-depth knowledge of the subject matter". Any method that relies on judgments by persons other than the authors themselves may suffer from reliability problems. This could be a particular problem in citation context and content analyses, which deal with difficult, often complex, and highly specialized subject literatures (McCain and Turner, 1989). Most published content analyses provide no operational definition for the judgment tasks and report no reliability coefficient for the decisions made by judges (e.g. Chubin and Moitra, 1975; Spiegel-Rösing, 1977).

To eliminate manual coding, some researchers have tried to link citation functions to explicit textual cues, such as the sections of scientific articles in which the citations are placed (Maricic *et al.*, 1998) and multiple mentions of citations in the same work

(Hooten, 1991). Researchers taking this approach are building on early work by Herlach (1978) and Voos and Dagaev (1976). Where citation functions are associated with explicit contextual markers, computers could classify citations[7] by recognizing the associations (White, 2001), and non-experts were able to note the location of the citation without any subjectivity (Maricic *et al.*, 1998). The results of a study by Maricic *et al.* (1998) showed that cursory or low intensity citations are dominant in the introduction section of papers, and meaningful or high intensity citations are dominant in methods, results, and discussion sections. Hooten's (1991) study revealed that multiple mentions in the same work can be taken as an indicator of a close relationship between citing and cited documents in the eyes of the citer. Hanney *et al.* (2003) could not find support for that relationship. With these contradictory findings, the extent to which explicit textual cues in citing documents can be used to determine the impact of cited works remains unclear.

The studies discussed above in section 2.5 on scientists' motivations to cite and not to cite show that authors have differing views as to the necessity for citations in their documents; and do not cite all works that have influenced their own work. These findings confirm earlier observations by Broadus (1971) and Smith (1981): "One author may cite all the material he used, even if remotely related to his study, while the other may cite only the most important . . . Actual use itself does not mean that the item was of supreme importance; the author might have used others had they been available" (Broadus, 1971, pp. 236-237). According to Smith (1981, p. 87), "certain documents are underrated because not all items used were cited, and other documents are overrated because not all items cited were used". However, the study by Kurtz *et al.* (2005) showed that reads and cites measured the same thing: the usefulness of an article. Do we then, as Cronin (2005a) asserts – in accordance with the normative theory of citing behavior – struggle to cite the most precise and most relevant work on a given subject, for the reason that few, if any, of us are wholly and authoritatively familiar with the scattered literature of our specialities?

After having reviewed and discussed the findings of the studies on citing behavior, we return to our starting point, the question of what citation counts measure. Even if many of the studies reviewed show methodological weaknesses and can hardly be replicated, the results suggest that not only the content of scientific work, but also other, in part non-scientific, factors play a role in citing behavior. Citations can therefore be viewed as a complex, multidimensional and not a unidimensional phenomenon. Why authors cite can vary from scientist to scientist.

On the basis of the available findings, should we then conclude that citation counts are not appropriate indicators of the impact of research? Not so, says van Raan (2005b, pp. 134-135, see also Van Raan, 2005a):

> So undoubtedly the process of citation is a complex one, and it certainly not provides an "ideal" monitor on scientific performance. This is particularly the case at a statistically low aggregation level, e.g. the individual researcher. There is, however, sufficient evidence that these reference motives are not so different or "randomly given" to such an extent that the phenomenon of citation would lose its role as a reliable measure of impact. Therefore, application of citation analysis to the entire work, the "oeuvre" of *a group of researchers as a whole over a longer period of time* (author's emphasis), does yield in many situations a strong indicator of scientific performance.

Van Raan's (2005b) assessment is supported by the findings of the bibliometric studies mentioned in the "Introduction", which at a high aggregation level demonstrated a clear association between citation counts and other assessments of scientific impact, such as peer judgments and the empirical tests of the two theories on citation behavior, the results of which – again at a high aggregation level – provide more support for a normative interpretation of the allocation of citations than for a social constructivist interpretation.

Van Raan's (2005b) distinction between low (the individual researcher) and high aggregation levels for citations follows an earlier general distinction made by Cole (1992) on the influence of social factors on the cognitive content of science. Cole (1992) distinguishes between local knowledge outcomes and communal knowledge outcomes. A local knowledge outcome is scientific work produced in a particular context by one or more scientist and may be influenced by social processes. A communal knowledge outcome is work that is accepted by the relevant scientific community as important and correct (the core of research), and it is more or less uninfluenced by social variables and processes. According to Cole (1992), therefore, at the micro-level (local knowledge outcome) we can agree with the position of the constructivists that the content of solutions to scientific problems is developed in a social context and through a series of social processes. In this sense, the content of science is socially constructed. At the macro-level (communal knowledge outcome), in phases in which "normal science" is conducted, the normative theory of science is correct. Core knowledge is characterized by virtually universal consensus. Scientists accept this knowledge as a given and as a starting point for their research.

Notes

1. Results in a similar vein are reported by Van Raan (2004b) in a paper titled "Sleeping beauties in science": "A 'sleeping beauty' is a publication that goes unnoticed ('sleeps') for a long time and then, almost suddenly, attracts a lot of attention ('is awakened by a prince')" (Van Raan, 2004b, p. 461). The calculation of an "awakening" probability function has shown that the probability of awakening after a deep sleep is smaller for longer sleeping periods. However, the results of studies by Van Dalen and Henkens (2004, 2005) call into question a time effect as an explanation for uncitedness over long periods. These studies investigated the extent to which uncitedness of articles published in demography journals accelerates over time. The results show that "the reasons why an article is not cited or cited relatively late, have to do with the journal in which the article appeared, certain visibility characteristics, and the reputation of the author(s). But perhaps the most important thing to notice is that the *absence of a duration effect* [acceleration of the authors] – after controlling for the above stated factors – indicates that a stigma of uncitedness plays no role in the timing of the first citation. The conclusion that an article will never be cited because it remained uncited for quite some years therefore seems unwarranted" (Van Dalen and Henkens, 2005, p. 228).
2. Results of a study by Archambault *et al.* (2005) show that there is a 20 to 25 percent over-representation of English-language journals in the databases of Thomson Scientific as compared to the list of journals presented in *Ulrich's Periodicals Directory* (2005).
3. An example of a (self-) critical view of citation counts as an indicator for scientific impact is found in an editorial in *Nature* (2005). With more than 1,000 citations, the most cited *Nature* paper from 2002 to 2003 was the mouse genome, published in December 2002. The editorial's criticism of the high citation counts is that the "paper represents the culmination of a great

enterprise, but is inevitably an important point of reference rather than an expression of unusually deep mechanistic insight" (p. 1004).

4. Although so far, none of the results of these studies have been adopted by Thomson Scientific or used in a widely available database (White, 2001) or "in 'normal' citation count-based studies" (Gläser and Laudel, 2001, p. 429). According to one anonymous referee of this review the obvious reason why Thomson Scientific has failed to adopt any richer method of analysing citations is that the proposed methods would be far more expensive than its current way of extracting citations. There is no convincing argument that such extra work would result in bigger sales and/or subscribers willing to pay more for the product.
5. Of studies published prior to the 1990s, we included in the present review only those that were the most important and influential; our review does not, therefore, consider unpublished studies, such as Finney (1979) and Johansson (1976). The results of those two studies are reported by Cronin (1984), for example.
6. The authors would like to thank two anonymous reviewers for their helpful comments and suggestions.
7. Garzone and Mercer (2000) described an "attempt to classify citations according to function in a fully automatic manner, that is, complete journal articles in electronic form are input to the citation classifier and a set of citations with their suggested function (chosen from a previously proposed scheme of functions) is output" (p. 337, see also Mercer and Di Marco, 2004). The results of a test of the classifier on real data show that only about 80 percent of the categorized citations are completely right classified; about 20 percent are partially right or completely wrongly classified. O'Connor (1980) obtained similarly unsatisfactory results in a first attempt at automated classification of citations.

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