Angewandte Chemie in Light of the Science Citation Index

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Fundamental Remarks

The call for objective and understandable criteria for the evaluation of research has led to science being increasingly confronted with citation numbers for its publications taken from data in the Science Citation Index (SCI). The SCI, which is an information service comparable to the classic abstracting journals, today is mainly used as a database and has been published by the American Institute for Scientific Information (ISI) in Philadelphia since 1963. The SCI owes its exceptional position to its interdisciplinary coverage and provides access to reference data in addition to bibliographic information and author abstracts. At present the SCI covers about 5700 journals for the natural sciences including medicine. Although, this core set only comprises about 10% of the scientific journals currently published periodically worldwide, it covers about 90% of all publications and more than 95% of all citations. Besides the Science Citation Index (SCI) there is the Social Sciences Citation Index (SSCI) as well as the Arts and Humanities Citation Index (A&HCI) which currently cover 3100 journals.[1]

Metaphorically speaking the citation network is the glue that links publications containing related content. The number of citations is a direct measure for the (documented) resonance or the impact, which a publication has created among colleagues. Resonance or impact, however, cannot be equated directly with importance or quality. The latter two are mainly shaped through interest and value concepts and thus cannot be measured objectively and quantitatively. Furthermore, the citation of other publications is not exclusively determined by purely factual considerations. The question as to what extent citation numbers are suitable for the evaluation of the quality of research has been frequently debated and will therefore not be discussed any further here.[2]

Evaluation of research through numbers of citations encompasses individual publications up to the complete sum of publications by one scientist, a research group, a research institute, or even a whole nation. Scientific journals too are ranked according to the number of their citations in the form of the Journal Impact Factors (JIFs), which have been published yearly in the Journal Citation Reports (JCR) by ISI since 1975.[3] *Angewandte Chemie* has been published since 1962 in the form of both a German and an International Edition, which has led to a number of problems with respect to citation analyses. Since *Angewandte Chemie* papers are contained in different volumes and appear on different page numbers in the two editions, these papers are compared and counted as if they were two completely different publications. Furthermore the way in which the two *Angewandte Chemie* editions are treated in the different literature databases is far from consistent.

One and the same publication may occur both as a citing and a cited publication in the SCI. Consequently, the name of a journal can occur saved in two different sections of the SCI: it can occur as part of the bibliographic information of the stored publications, comparable to other literature databases. Here only the selected core journals are covered, whose information has been standardized and in the case of *Angewandte Chemie* only the International Edition is considered. Furthermore, in the SCI, journal information forms part of references assigned to publications. These have been standardized with regard to authors and numerical information (publication year, volume and page numbers); however they contain the names of the journals in exactly the same form as they have been cited by the authors. References to papers in *Angewandte Chemie* relate to either one or the other edition or even both editions (double citations), as practiced, for example, for references in papers in *Angewandte Chemie* to other *Angewandte Chemie* papers.

Citations of Individual Publications

The search options available through STN International (see Fachinformationszentrum Karlsruhe), in particular the introduction of functions for carrying out statistical investigations, have made it possible to perform extensive citation analyses directly online. Such investigations were hitherto only reserved for the SCI producer and for a few research institutions specializing in this area. The findings presented herein result from using the database SCISEARCH (SCI under STN International).[4]

Investigations in which the publications under evaluation are exclusively recorded in the SCI (standard procedure),

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only consider the International Edition of *Angewandte Chemie* and consequently only count the citations that have been made in the form of this edition. The citations of the German Edition are only considered when they are made in addition to the citations of the International Edition as done by some authors. As an example the citations of a paper by Martin Jansen were investigated. (*Angew. Chem.* **1987**, *99*, 1136–1149; *Angew. Chem. Int. Ed. Engl.* **1987**, *26*, 1098–1110). The total number of citations as well as the share of those for the German and for the International Edition can be taken from the alphabetical list of all the references saved in the SCI of all the stored publications (STN EXPAND list). However, this list, which can be retrieved in the form of extracts, is only of use for investigating individual publications (with known first author), and for practical reasions is not used, for example, in the investigation of the citations of all publications of a scientist.

Accordingly, the paper by Jansen was (up to May 12, 2000) (correctly) cited 123 times in the form of the International Edition and 68 times in the form of the German Edition. The sum of 191 citations is, however, by no means the final result. Some authors cite both editions, which in this case occurred 37 times; thus, in about 20% of all citations. Consequently, 154 citations are counted in the final analysis. In an evaluation of all publications by Jansen by the standard method, this paper would be listed with 123 citations; thus lacking the number of citations exclusively in the German Edition and therefore more than 20% too low. Also a search in the Web of Science (WoS), the search platform provided by the producer of the SCI directly (i.e. not from one of the other database providers such as STN) and currently very widespread, revealed that the SCI listed 123 citations for the same paper by Jansen.

The underestimation of papers in *Angewandte Chemie* varies individually and depends generally on the timeframes of their citations. Underestimation results in a significant loss of information, since the SCI is mainly used to access contents and to investigate factual details by way of the citations. Eugene Garfield, the founder of SCI, did not so much have the evaluation of research in mind but rather the search of literature through citations rather than through the often problematic keywords.

STN International offers its customers the possibility to convert the bibliographic data of the stored publications not only of SCI, but also of most of the available literature databases in such a way that subsequently they can be searched for in the form of references in the SCI. In this way it is possible to determine the citations of all the publications of a certain author regardless of the position of his name in the authors' field. Literature entries under STN International can thus, for example, occur with inclusion of Chemical Abstracts (database clusters: CA or CAPLUS+SCISEARCH), in which at least up until 1994 (inclusive) both editions are compared (since 1995 Chemical Abstracts like the SCI has only considered the International Edition). However, in the case of a ranking the citation numbers are listed individually for each edition which results in a lower ranking. A correct summary of the citation numbers of the corresponding issues of the two editions would only be possible through a concordance list.

The Journal Impact Factor (JIF)

Without doubt *Angewandte Chemie* belongs worldwide to the top group of chemical journals, which is also demonstrated by an unusually high Journal Impact Factor (JIF). In the past the question was repeatedly asked whether the high JIF of *Angewandte Chemie* truly reflects the real impact of the journal, or as a result of double citations of both editions contains an overestimation.[5] To establish the JIFs the publications of a journal are taken into consideration over a period of two years and their citations are then determined over the following year. The number of citations is then divided by the number of citable publications (i.e. Communications, Highlights, and Reviews) in the two preceeding years. The JIF98, for example, considers the publications from the years 1996 and 1997 and their citations in the year 1998.[3]

The annually published JIFs in the Journal Citation Reports (JCR) from ISI are determined by "Journal Title Matching". For the determination, for example, of the JIF98 the number of citable publications in the years 1996 and 1997 was initially established. It is then investigated how often the journal name (in all the different variations in which it appears) occurs in combination with the publication years 1996 and 1997 in the reference sections of the publications of the year 1998. Finally, the quotient is derived from the counted publications and their citations. This process has the advantage that the incorrect citations are also considered since the name of the first author and the numerical data of the references are not taken into consideration.

Alternatively, the references of all stored publications can be searched to find out whether and how often each individual (previously fully recorded and not only counted) *Angewandte Chemie* paper from a two-year time interval was cited in the following year. This search is generally always carried out through only the name of the first author, the publication year, the volume number, and the first page. The journal name is not taken into account here due to a lack of standardization. This "Citation Matching" works significantly more selectively and provides distinctly lower citation numbers: only the citations of the International Edition are counted, (correctly) no multiple counting through double citations occurs, and the incorrect references are not part of the total sum. Based on the citation variants of frequently cited papers it can be shown easily that on average about 5% of all references stored in the SCI are incorrect with regard to the numerical data they contain. In the case of *Angewandte Chemie* citations an added factor is that some of the citing authors mix up the editions and attribute the numerical data (here volume number and first page) to the wrong edition. Sometimes volume numbers or page numbers of the two editions are also mixed up.

Both procedures for determining the JIF are generelly also available for the investigation in the online database of the SCI available through STN International. Table 1 summarizes the data from the Journal Citation Reports (JCR) 1998 (the most recent JIFs of ISI in May 2000) and the results of the online investigation in connection with the determination of the JIF98 of *Angewandte Chemie*. The numbers in the second and fourth column have been determined through "Journal Title Matching", that is by means of the same process and can

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Table 1. A comparison of the number of publications, citations, and the value of JIF98 for *Angewandte Chemie*, determined from ISI (Journal Citation Reports (JCR) 1998) and from the online database of the SCI available through STN International.[a]

	JCR (1998) Journal Title Matching	Online (STN) Citation Matching	Online (STN) Journal Title Matching
publications (1996+1997)	1296	1299	1299
citations (1998) German Edition	–	[b]	2355
citations (1998) International Edition	–	6102	8089
citations (1998) both editions	10405	[b]	10444
JIF98 International Edition	8.03	4.70	6.23
JIF98 both editions	–	[b]	8.04

[a] The somewhat different numbers for publications and citations, respectively, in columns 2 and 4 are caused by nonidentical timeframes. [b] Not possible since the German Edition is not considered in the bibliographic section of the SCI.

thus be directly compared with each other. It is shown that the JIF98 of 8.03 determined by ISI is obviously valid for both *Angewandte Chemie* editions together and not only for the International Edition. This also largely explains the differences found by various authors when they compare the ISI data with their own results (on the basis of "Citation Matching").[5] They simply compare the JIFs supposedly determined by ISI for die International Edition with their own JIFs, which indeed only refer to this edition. The former are overestimated because of double citations, however, this only partly explains the differences.

For the "Citation Matching" (third column), double citations are avoided, however, at the same time the citations of only the German Edition as well as the incorrect citations (whose percentage is particularly lage due to the two editions) are excluded. Accordingly, the difference between the JIFs for the International Edition (4.70 and 6.23) is caused by the consideration of inconsistencies in the "Journal Title Matching". The difference of the JIFs of the International Edition in relation to both editions together (6.23 and 8.04) results from both (incorrect) inclusion of double citations and the additional consideration of the citations of only the German Edition in the "Journal Title Matching" for both editions.

The consequences of citation errors become evident on comparing the tables of the citations of individual papers on the basis of the two counting procedures: on the basis of "Citation Matching" the head of the table lacks in addition to other papers the two most frequently cited reviews because their first page has been saved one unit too high in the bibliographical section of the SCI. As a result the percentage of citations with the correct first page (here 140 of 163, and 108 of 135 citations, respecitvely, corresponding to 80 and 85%, respectively) is not included in the calculation, but merely the smaller percentage of the incorrect citations since even some citing authors cite the first page one unit too high.[*] It remains to be investigated to what extent such errors occur for reviews in *Angewandte Chemie*. They do not influence the JIF, however for the evaluation of reviews in *Angewandte Chemie* according to the standard process they lead to an additional, this time even larger underestimation.

[*] Editorial note: Since 1996 reviews in *Angewandte Chemie* have begun with a full page picture (frontispiece). This page is always the first page of the review.

Citations of the German and International Edition

The time-dependent proportion of the publications citing the individual issues has been determined through "Journal Title Matching". Figure 1 shows the citing publications since 1974 (first year of the database), which have at least made one citation of the German or the International Edition, respectively. A citing publication can contain several *Angewandte Chemie* references as citations (on average 1.65 *Angewandte Chemie* citations per citing publication). The numbers contain the *Angewandte Chemie* citations of papers of any given

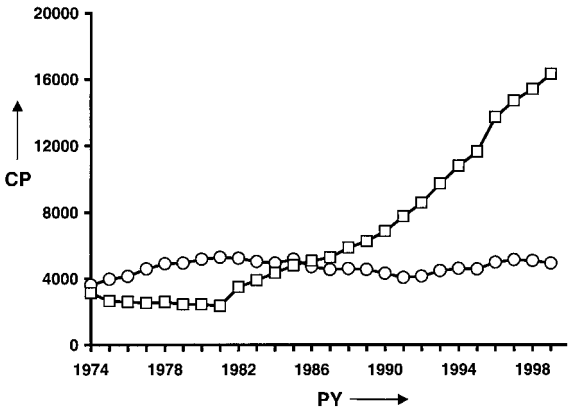

Figure 1. Number of publications (CP) that cite *Angewandte Chemie* papers as a function of the year of publication (PY) of the citing publications, separated according to citations for the German Edition (circles) and for the International Edition (squares) and determined through "Journal Title Matching" (including double citations, incorrect citations, and journal self-citations).

Angewandte Chemie volume, instead of only those of two *Angewandte Chemie* volumes as in the case of the JIF formula. Accordingly, the citations of the International Edition have increased steadily since 1981, whereas those of the German Edition have remained relatively constant. At present the International Edition contributes about 70% and the German Edition provides only 30% to the total number of citations.

Figure 2 shows how the percentage of publications that exclusively cite the German Edition (also determined through "Journal Title Matching") has changed over time. In 1998 this percentage was only about 10% (based on *Angewandte Chemie* papers from 1996 and 1997 even as low as 5%); however, over the complete period from 1974 up to the present it averaged almost 30%. Older publications on average are underestimated by this percentge (see above). In this context it has to be taken into consideration that in addition to the impact which is documented in the form of citations there exists an impact which cannot be measured. The impact of the German Edition on numerous industrial chemists and students among the readership, for example, is hardly documented in the form of citations, however, it undoubtedly exists.

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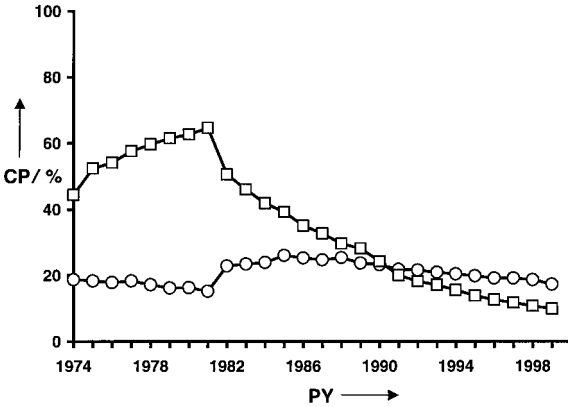

Figure 2. Percentage of the double citations (circles) among the citing publications (CP) as well as the publications exclusively citing the German Edition of *Angewandte Chemie* papers (squares) as a function of the years of publication (PY) of the citing publications, determined through "Journal Title Matching" (including incorrect citations and journal self-citations).

The Extent of Double Citations

In the determination of the JIF98 it was established that of the 5295 publications citing *Angewandte Chemie* papers 1124 (21 %) simultaneously contained at least one *Angewandte Chemie* paper in the period 1996 – 1997 as a citation of the German as well as one of the International Edition. However, this number also includes those publications which cite a paper in the German Edition and a totally different paper from the same period as the International Edition. The value of about 20 % for double citations thus is an upper limit. Owing to the lack of a concordance list the corresponding publications of the two editions could not be exactly identified. The manual comparison of 100 of the 1124 papers with regard to real double citations (same first author, volume difference = 73, similar first page) showed a value of about 80 %; that is 16 instead of 20 % double citations related to all citing publications.

Accordingly, the JIF98 of about 8.0 for both editions of *Angewandte Chemie* given by ISI (for the International Edition) and verified by an online search is about 15 % too high. However, even the corrected JIF98 is still very high at a value of about 6.8 and thus changes very little regarding the positioning of the journal. This value is, for example, still higher than that of the *Journal of the American Chemical Society* (*J. Am. Chem. Soc.*) of 5.73 (JIF98). However, the two journals can hardly be compared directly with each other owing to their different composition with regard to mauscript types (percentage of Communications). Figure 2 shows how the percentage of double citations has changed over time, like in Figure 1 related to the total number of all *Angewandte Chemie* citations. For 1998 the upper limit lies again at 20 %. Of the 1124 papers citing both editions 336 (30 %) were published in *Angewandte Chemie* papers (journal self-citations); however, over the whole period from 1974 up to the present the mean value is only 15 %.

To summarize: The exclusive consideration of the International Edition in the bibliographic section of the SCI in the case of an evaluation through standard processes results in an underestimation of *Angewandte Chemie* papers by the percentage of citations which occur exclusively in the German Edition. Additionally, reviews can experience a drastic underestimation due to incorrect storage or citation of the first page. The evaluation of the journal as a whole through its Journal Impact Factor (JIF), however, leads to an overestimation by the percentage of citations from both issues of the same paper (double citation). The reason for this seeming contradiction are the different processes used for determining the citation numbers, which in one case (in the case of individual papers) compare all numerical data of the publications, whereas in other cases (in the case of the JIF determination) count the mentions of journal names.

Citations of Reviews and Communications

Since the 1950s the contributions to *Angewandte Chemie* have been divided into the two large categories Reviews and Communications. In the bibliographic section of the SCI the 1322 publications in *Angewandte Chemie* from 1996 and 1997, for example (which were used to determine the JIF98), are divided into the following document types: 1213 "Articles", 86 "General Reviews", 14 "Errata", 5 "Letters" and 4 "Editorials". Here the "Articles" correspond to the "Communications" and the "General Reviews" correspond to the Reviews. Before 1990 the larger part of the "Communications" (ca. 80 %) was categorized as the document type "Note", which, however, was not used any more after 1995. Since 1992 "Communications" have been exclusively classed as "Articles".

The separate evaluation of Reviews and Communications is only possible through "Citation Matching" because only this process generates a complete set of data for the evaluation of the publications, thus allowing a categorization according to document types. Since this process only considers citations from the International Edition and undertakes an accurate comparision of the references (incorrect references are not counted) the absolute numbers with regard to the Impact (citations and citations per publication, respectively) are too low and cannot be compared to the JIF98 data. However, the data can be used for determining the relative percentages. The separate evaluation of Reviews and Communications has been undertaken analogously to the determination of the JIF98 and is summarized in Table 2.

It is shown that in 1998 the Reviews from 1996 and 1997 were already cited almost twice as often as the Communications. A longer period (i.e. a longer timeframe for the citations than the one used for the JIF formula) results in a

Table 2. Relative impact of Reviews and Communications in *Angewandte Chemie* based on the JIF98, determined by "Citation Matching" through the online database of the SCI available through STN International.

	Publications 1996 and 1997	Citations in 1998 only	Citations per publication
Angewandte Chemie Reviews[a]	86	655	7.62
Angewandte Chemie Communications	1213	5447	4.49
Reviews plus Communications	1299	6102	4.70

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further shift of the citation numbers in favor of Reviews. And this despite the fact that Reivews are prone to be underestimated due to the problems with their first page. However, since the number of Communications is around an order of magnitude higher than the number of Reviews the high citation numbers of the Reviews do not have a dramatic effect on the total impact.

Citation Behavior of Individual Publications as a Function of Time

The citation behavior of individual publications as a function of time reflects to what extent and how rapidly a particular publication has been received by colleagues. Figure 3 shows the development with time of citations of two

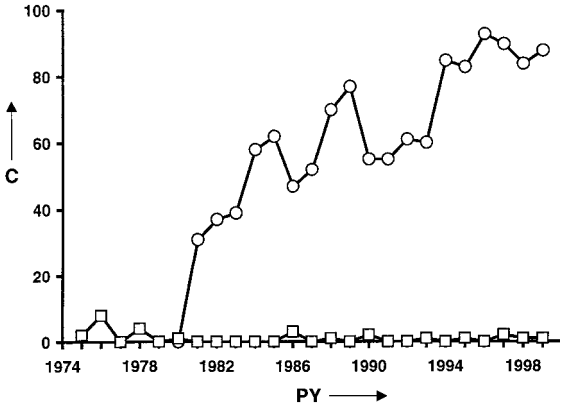

Figure 3. Number of citations (C) of a highly cited paper (*Angew. Chem.* **1980**, *92*, 343 – 361; *Angew. Chem. Int. Ed. Engl.* **1980**, *19*, 344 – 362) with 1245 citations (circles) and of a seldomly cited paper (*Angew. Chem.* **1974**, *86*, 594 – 595; *Angew. Chem. Int. Ed. Engl.* **1974**, *13*, 552 – 553) with 28 citations (squares) as a function of the year of publication of the citing publication.

publications from Wolfram Saenger, one of which is the most highly cited paper from *Angewandte Chemie* from 1980 with 1245 citations (up to May 12, 2000). Its curve is typical of many highly cited papers just as the one of the second paper can be seen as typical for the large number of the less highly cited papers.

Strictly speaking the citations of each publication develop according to their own particular characteristic time curve. However, on investigating many such time curves, some common features are evident: Noteworthy resonance for a publication in the field of chemistry or physics generally only sets in after one to two years, reaches a maximum after about three years, and can then continue for decades. Highly cited publications often reach the maximum of their citations only after decades and sometimes show an almost constant resonance over the course of decades. Most publications, however, have a lower, often extremely oscillating effect, which can nevertheless continue for a long time. Consequently a certain period of time has to pass before the resonance of a paper (or the work of a scientist) can be realistically measured to some extent through the number of citations.

The timeframe of the citations in the determination of the JIFs by ISI permits only an average period of two years (at least one year, maximal three years). Therefore, only the first rise is calculated, which says little about the long-term impact (for example, about the one measured after one decade). JIFs thus measure more the speed of the resonance rather than its degree. The former, however, should be the reserved for the "Immediacy Index" given in the JCRs (which only considers citations within the year of publication). The narrow timeframe of the citations in the JIF formula leads to an underestimation particularly for highly cited papers (to which several of the reviews in *Angewandte Chemie* belong) because they accumulate a large percentage of their citations at a later period. The highly cited paper from Saenger, for example, had accumulated only 5 % of its total citations to date in the first three years after its appearance. In several areas of biological sciences the reaction in the form of citations occurs more rapidly, so that there the ISI formula for the determination of the JIFs is more valid. However, for chemistry (and physics) its application is questionable. It is presumably used by ISI, in an effort to be able to offer the most up to date JIFs. Apart from the possibilities for errors which lie in the nature of journals, the short timeframe of the citations demand great caution in the application and in the interpretation of JIFs.[6]

[1] a) E. Garfield, *Citation Indexing – Its Theory and Application in Science, Technology, and Humanities,* Wiley, New York **1979**; b) URL: http://www.isinet.com/isi/hot/essays; c) URL: http://www.isinet.com/isi/products

[2] a) G. Taubes, *Science* **1993**, *260*, 884 – 886; b) M. H. MacRoberts, B. R. MacRoberts, *J. Am. Soc. Inf. Sci.* **1989**, *40*, 342 – 349; c) J. Reedijk, *New J. Chem.* **1998**, 767 – 770; d) W. G. Stock, *Spektrum Wiss.* **1995**, *11*, 118 – 121.

[3] a) E. Garfield, *Science* **1972**, *178*, 471 – 479; b) *"Journal Citation Reports" (JCR)*, Science Edition, Institute for Scientific Information (ISI), Philadelphia, **1998**; c) URL: http://www.isinet.com/isi/search/glossary

[4] a) C. F. Huber, *Database* **1995**, *18*, 52 – 62; b) STN International: *STN Guide to Commands* **1997**; c) URL: http://www.fiz-karlsruhe.de/stn/messenger/mc-toc.html; d) URL: http://www.fiz-karlsruhe.de/stn/databases/scisearc.html

[5] a) T. Braun, W. Glänzel, *Chem. Intell.* **1995**, 31 – 32; b) T. N. van Leeuwen, H. F. Moed, J. Reedijk, *Chem. Intell.* **1997**, 32 – 36; c) H. F. Moed, T. N. van Leeuwen, J. Reedijk, *Scientometrics* **1996**, *37*, 105 – 116.

[6] a) P. Mestecky, *Mater. Today* **1998**, *1*, 8 – 12; b) I. A. Williams, *Chem. Br.* **1996**, *32*, 31 – 33; c) P. O. Seglen, *BMJ* **1997**, *314*, 498 – 502; d) E. Zass, *Chimia* **1999**, *53*, 253 – 255.

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