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Citations in Web 2.0

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Citations are a classic dimension of scientific communication. This paper looks at two different scenarios in which citation analysis can be applied to novel Web 2.0 environments: One case study deals with citations on Twitter and the other with analyzing blog posts and social bookmarking systems.

Introduction

Scientific communication is a process that, among other things, involves citing other scholars' publications. Therefore, it is not surprising that citation analysis has become one key method for investigating relevance and importance in academia (see, e.g., Cronin, 1984). Citation analysis can thus have practical implications for scientists' work and life, because it is used to evaluate the impact of individual scientists, working groups, institutions, or scientific journals, and may be the basis for decisions about funding grants and job appointments (Stock, 1994; Stock, 2001). Furthermore, citations help scientists to filter the enormous amount of scientific literature and allow browsing and searching in publication databases such as Web of Science and Scopus, thus becoming part of information retrieval strategies. Accordingly, the quality, comparability, and adequacy of applied methods in citation analysis are of high importance. The scientific disciplines of informetrics (Tague-Sutcliffe, 1992) and, more specifically, scientometrics deal with these key challenges and establish procedures for measuring and comparing scientific output based on publications and scientific reputation based on citations (Haustein, 2012; Leydesdorff, 1995).

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With the growing importance of the Internet, the principles of informetrics have also been applied in Web environments, thus shaping the new discipline of webometrics (Thelwall, 2008). The fundamental principle of the Internet is a connection via hyperlinks; hyperlinks interlink Web sites with each other and thus build the World Wide Web. Smith (2004) showed that Web links resemble patterns of classic citations in printed publications. References or footnotes in printed publications and links on Web sites are the keys for finding relevant information in both search engines and bibliographies. In addition to these hyperlink structures, recent Web 2.0 tools come with a number of other important functionalities that enable novel forms of social interaction. They have brought about new aspects that can be measured in webometrics (e.g., those relating to access and usage, Web publication behavior, and user interrelations).

Scientific discussions are also increasingly being held in various Web 2.0 environments such as blogs, forums, and Twitter. Gray et al. (2008) pointed out that scholars were acting as authors in different Web 2.0 environments, including wikis, podcasts, and blogs—a development that challenges the classic understanding of the authorship concept in scientific communication. Gray et al. (2008) also discussed the difficulties of quoting and citing Web 2.0 sources in scientific publications. Currently, activities outside classic publication channels such as scientific journals are rarely considered in official evaluations of scientists' impact and scope. Yet, with the growing importance of using the Internet in scientific communication, there is a need for discussing combinations of scientometric and webometric indicators. So far, the most notable effort to promote and discuss alternative scientometric indicators for Web environments has been the altmetrics initiative (Priem et al., 2010). The authors of the altmetrics manifesto argued for the development of new metrics that would enable filtering and browsing of the growing amount of information on the Web. Priem and Hemminger (2010), furthermore, provided an overview on Web 2.0 services, which might be of interest for new scientometric indicators (e.g., measuring publication impact on the basis of social mentions). This paper represents our own contribution to this ongoing discussion.

In citation analysis, one typically distinguishes citations from references, which actually are two sides of the same coin (Stock, 2001). Slightly inconsistently, citation is also used as a broader term that subsumes both the dimension of citations as well as the dimension of references; this fact often leads to confusion and inconsistent use. If an author cites an exact passage from a text, this is called a quotation. If a publication includes a formal mention of another work, there is a linkage between these two publications that can be looked at from two perspectives. From the cited work's perspective, this linkage is a citation, received by the cited author. From the citing work's perspective, the linkage is a reference: The citing author has referred to another work (usually in the References section or as a footnote).

The Web 2.0 has created lots of new types of references. Let us have a look at some examples: The microblogging service Twitter allows users to easily cite other users' tweets by retweeting them (boyd et al., 2010) and including additional hyperlinks. Blogs may also include hyperlinks as references. Furthermore, trackbacks or pingbacks automatically inform bloggers when other blogs cite them (Kim & SangKi, 2008). With social bookmarking, users indicate interests in scientific publications via sharing URLs or Web resources. These are only some of the Web 2.0-related examples, at which we will have a closer look in the subsequent sections. There are various others, but they are beyond the scope of this article. In summary: On the one hand, various new forms of social content may receive citations, because people may cite YouTube videos, SlideShare slides, or podcasts. On the other hand, various types of Web 2.0 contents include references to either classic publications (e.g., a blog post linking to a journal article) or to other types of social content (e.g., a tweet referencing a blog post).

We will now present the results from two different case studies. First, we will look at types of citations that can be found on Twitter. Second, we will analyze the linking behavior of scientific bloggers and the visibility of bloggers' publications in different social bookmarking systems (for example, Mendeley) and bibliographic databases (e.g., Scopus). Both offer preliminary results in the area of citations in Web 2.0 and should encourage future research in this area.

Citation Analysis in Twitter

Priem and Costello (2011) defined citations in Twitter as "direct or indirect links from a tweet to a peer-reviewed scholarly article online" and distinguished first and second-order citations, based on whether there is an "intermediate webpage between the tweet and target resource." They collected tweets from 28 academics and found that, of all URLs in these tweets, 6% were links to peer-reviewed articles (either directly or via an intermediate page), which could be counted as citations. We have argued that linking to a peer-reviewed publication is only one possible dimension of citing with Twitter and used different, alternative definitions (Weller et al., 2011; Weller & Puschmann, 2011). The basis of our definition is the distinction between external citations and internal citations. Tweets may either include references to external resources or to information available on Twitter.

All URLs in tweets can be considered as a citation act: The tweet includes a reference in the form of a URL, and a certain Web site obtains a citation through this tweet. For some scientometric analyses, references to scientific publications are of the greatest interest, and the approach of Priem and Costello (2011) for counting those URLs might suffice. Yet, references to scientific blog posts, news articles, or presentation slides may also be valuable information. For example, Thelwall et al. (in press) look at links to science-related YouTube videos. Moreover, for general informetric analyses, all sorts of references to URLs are of relevance and should thus be considered as types of citations.

As Twitter itself is a channel for communicating and publishing pieces of information, we can also find a different type of citation behavior: Quite frequently, Twitter users directly quote other peoples' tweets. Tweets are either copied completely, or users copy parts of an existing tweet and add their own comment. In many cases, the users also mention the original author—this clearly resembles citation practices in scientific communication. Because these copied tweets have often been labeled as "Retweets" or "RT" by Twitter users, Twitter has established retweeting as a genuine Twitter functionality (Kooti et al., 2012). Retweets can thus be interpreted as a form of inter-Twitter citations (internal citations). A user who retweets another user's tweet publishes a reference: The retweeted user receives a citation. In general, users retweet for different reasons, such as information diffusion, or use retweets as a "means of participating in a diffuse conversation" (boyd et al., 2010). Retweet analyses can help to identify influential Twitter users, interesting topics on Twitter, and information diffusion—much as citation analysis can do in classic publication databases. Because Twitter has now largely standardized the format of retweets (when the specific retweet button is used on Twitter), retweet analyses can be performed more easily and become more reproducible. However, for altmetric analyses, some technical challenges remain when users manually modify retweeted statements.

Selected Results

Having defined these two different types of Twitter citations, we will now take a closer look at actual Twitter data to see how they are applied in scientific communication. We looked at different sets of "scientific tweets," i.e., tweets that can be interpreted as scientific communication. In our cases, these tweets were either collected based on specific hashtags for scientific conferences or based on the tweets' authors (Weller et al., 2011). We chose single conference hashtags and used a list of almost 600 Twitter users who identify themselves as scientists or people closely related to academia (Weller & Puschmann, 2011). Table 1 includes basic information for the three datasets and summarizes the proportions of internal and external citations in these tweets. These datasets reveal high citation activities in science-related tweets. Whereas only three percent of general tweets are retweets (boyd et al., 2010), the conference tweets and the scientists' tweets all have more than 20% RTs.

Table 1. The three test datasets and the proportion of internal and external citations

Dataset	#www2010	#mla09	scientists
Description	World Wide Web Conference (WWW 2010), Raleigh, NC, USA. April 26-30, 2010.	Modern Language Association Conference (MLA 2009), Philadelphia, PA, USA. Dec. 27-30, 2009.	Tweets collected from 589 selected science-related Twitter users.
Data collection period	4/13/10 to 5/14/10	12/15/09 to 1/14/10	1/7/10 to 8/31/10
No. of tweets	3,358	1,929	410,609
No. and % of external citations (URLs)	1,338 40%	525 27%	227,550 55%
No. and % of internal citations (RTs)	1,121 33%	413 21%	92,225 22 %
No. and % of retweets that include URLs	530 47%	270 65%	58,525 63%

Notice also a very high number of external citations in scientists' tweets: Fifty-five percent of the tweets contained at least one URL. Some tweets also included more than one URL, so the number of total URLs in the datasets is even higher. For example, in the #www2010 dataset, 1,338 tweets include at least one URL. There is a total number of 1,460 URLs in the dataset. These URLs may reference the same Web sites. In the #www2010 dataset, there are 574 unique Web sites linked by 1,460 URLs. For the conference datasets, we have considered the cited URLs and manually classified them into 10 categories (see Figure 1). Users in the #mla09 dataset almost never cited actual scientific publications in their tweets. More frequently cited were blog posts and press articles. For #www2010, the distribution is more balanced. Finally, our analysis showed that internal and external citations on Twitter are also highly interwoven. More than half of the retweets (63%) in the scientist dataset included URLs (65% for #mla09 and 47% for #www2010; see Table 1). This finding suggests that Twitter is heavily used for re-sharing information resources.

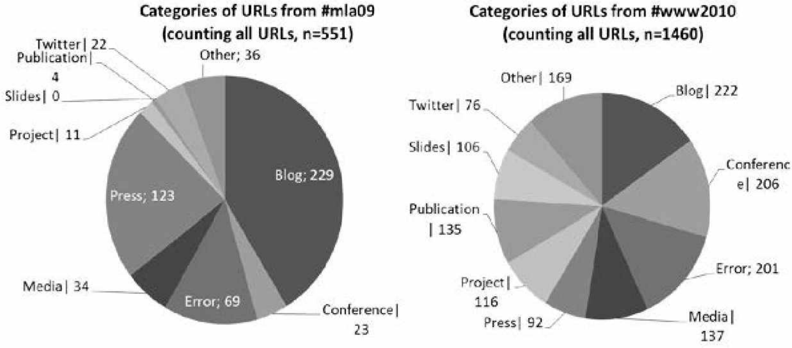

Figure 1. URLs from #mla09 and #www2010 by categories

Citations in Blogs and Social Bookmarking Services

Blogs are typically personal Web sites where published posts are displayed in reverse chronological order (see, e.g., Puschmann, 2010). They serve as easy-to-publish media and are therefore increasingly used by scholars (Luzón, 2009) to discuss the latest research with their peers and other audiences (Mahrt & Puschmann, in press) and as a means of self-reflection (Reinmann, 2008) or education. Linking is a fundamental part of blogging practice, with pingbacks and trackbacks informing bloggers when their blog was cited by another blog. Additionally, blog posts often contain URLs to various Web resources (creating external citations) or to sites within the same blog(-platform), which might be regarded as an instance of self-citation (see, e.g., Shema et al., 2012). Luzón (2009) analyzed linking behavior and link types of 15 academic blogs and found that over 50% of links point to pages within the same blog.

In social bookmarking services (for example, Delicious), users, browser-independently, save and tag Web resources, such as blogs or Web sites, for later retrieval. Scholarly social bookmarking services also allow the saving of bibliographic information for scholarly products (Reher & Haustein, 2010). Analogous to citation counts, bookmarks to publications can be seen as indicators of how interested a community is in a given publication (Haustein, 2012). Groth and Gurney (2010) analyzed which and how chemical journal articles are discussed on ResearchBlogging.org (e.g., in terms of the impact factor of the journal), whereas Shema et al. (2012) investigated the demographics and topical foci of bloggers from the same platform. Bar-Ilan et al. (2012) studied publication lists and publications found in Scopus and in social bookmarking systems of 57 presenters from the 2010 Leiden Social Technology Indicators (STI) Conference. They found that in Mendeley, more than 80% of the 1,136 sampled articles were saved by users. Moreover, Mendeley bookmarks are significantly correlated (r = 0.45) to Scopus citations. Correlations among Mendeley, CiteULike, and Web of Science for 1,613 Nature and Science articles were also processed by Li et al. (2012). Web of Science and Mendeley showed a moderate correlation of r = 0.55 and CiteULike a correlation of r = 0.34. Ninety-two percent of the sampled articles were also bookmarked by at least one user in Mendeley and 60% by one or more CiteULike users. In the following sections, we will explain our research questions and present the results of our own study on blogs and social bookmarking systems to compare them with the results found in related work.

Data Collection

Scientific blogs were our key information source in this study because they determined the selection of the analyzed authors. We used two blog portals, Scienceblogs.com and Scienceblogs.de, which host blogs of scientific writers. We only considered authors who are affiliated with universities or other research institutions. This limitation resulted in 33 English-language authors and 11 German-language bloggers. Because some blogs are maintained by more than one author, we combined the authors of each blog and analyzed data from 30 English and 10 German blogs indicated by their respective authors' names. For all of the chosen blogs, we manually collected the blog's name, the name(s) of author(s), the blog's starting date, and the number of blog posts, comments, and unique commentators. Moreover, we automatically extracted the URLs of the blog posts to analyze linking behavior of bloggers. The analysis is based on 19,721 blog posts. For author-based citation statistics, we employed the same approach as Bar-Ilan et al. (2012) and used Mendeley, BibSonomy, and CiteULike to extract social bookmarking data for each article that a blog author had written. To gain article-based metrics as well as bookmarking statistics, we first searched for the official publications lists of chosen bloggers on institutional or private Web sites. Here, we worked with individuals and not blogs. We considered publications lists found on institutional or private Web sites as a gold standard, because we assumed that scientific authors are strongly interested in regularly maintaining their publications lists to be visible in the scientific community. However, some authors did not have any publications lists, so we had to create such lists from publications found in the analyzed social bookmarking systems. We also cross-checked social bookmarking systems to find articles missing on the publications lists and to determine the share of "official" papers (recorded in self-maintained publications lists) in social bookmarking systems. Authors without publications lists or articles saved in social bookmarking systems were excluded from analyses. Authors were also excluded when author disambiguation was too difficult because self-maintained publications lists could not be found on the Web (e.g., Jessica Palmer). In sum, we analyzed 936 publications found on personal publications lists and social bookmarking systems by 41 authors. To compare social bookmarking data with traditional author metrics provided by bibliographic databases, the number of publications and citations found in Scopus was also collected. We chose Scopus as the source for citation data because it allows users to search for authors by first and last name. Because Scopus only indexes a selection of available journals and other publication formats, we only gained data from 678 publications, meaning that about 28% of the publications of the analyzed bloggers could not be found in Scopus. This value is slightly higher than those reported by Bar-Ilan et al. (2012) and Li et al. (2012), probably because of the smaller dataset used in our study.

Results

The use of URLs is common practice in blogs, as shown in Figure 2. Especially heavy bloggers distribute URLs via blog posts (e.g., Lambert).

However, the shares of outgoing URLs linking to Web sites outside the blogs and to other blog posts (i.e., self-citation) differ fundamentally among blogs. Table 2 shows the 10 most linked top-level domains from scienceblogs.com and scienceblogs.de. Other social media platforms, such as Wikipedia, YouTube, or Twitter, and news platforms (e.g., The New York Times or Spiegel) are mostly referenced in blog posts, besides self-reference to scienceblogs.de or scienceblogs.com, which are the top-link destinations in our dataset. The results for self-citations correspond to those found by Luzón (2009) for scienceblogs.de but are lower for scienceblogs.com, which might be explained by our automatic analysis focussing on top-level domains.

Surprisingly, it turned out that self-maintained publications lists are not complete or updated frequently by authors. Twenty-two percent of the publications from authors of scienceblogs.com and 25% of publications from authors of scienceblogs.de are only findable via author-name searches in other sources (i.e., Scopus, CiteULike, Mendeley, and BibSonomy). The detailed analyses of the three social bookmarking systems showed that, for both author groups, Mendeley is the service where most of the publications can be found (53% in scienceblogs.com and 42% in scienceblogs.de).

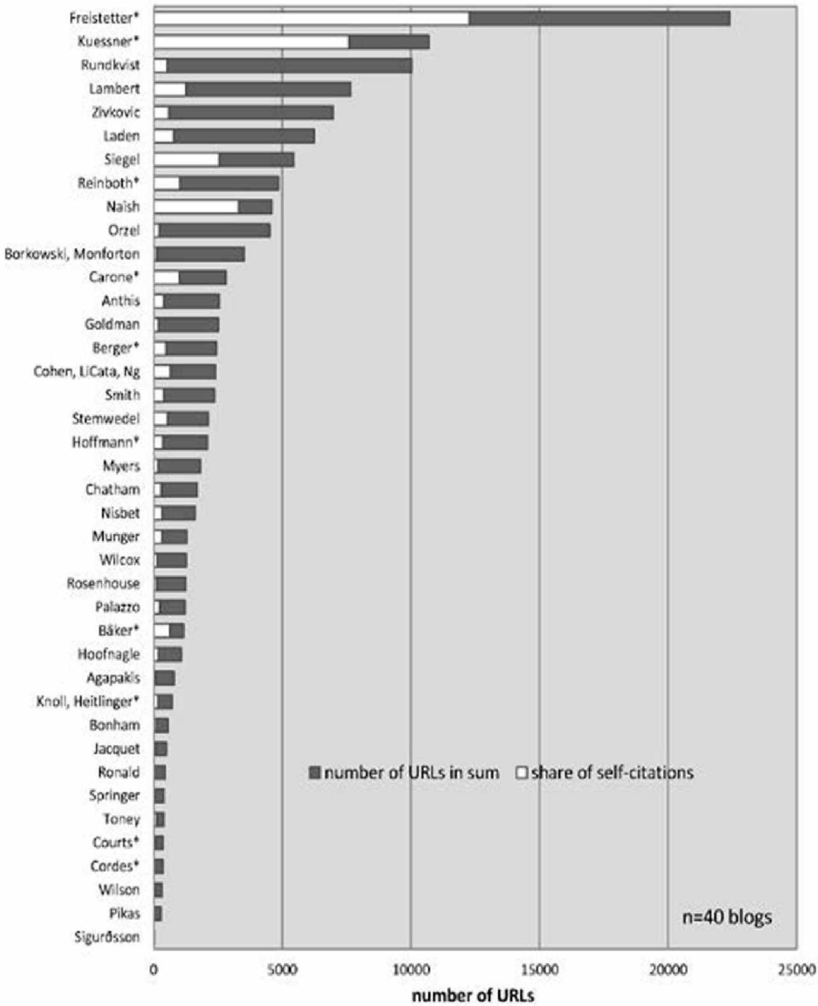

Figure 2. Number of URLs in blog posts and self-citations. * = Scienceblogs.de authors

Table 2. Link destinations from scienceblogs.de and scienceblogs.com

outgoing links from blog posts (scienceblogs.de)			**outgoing links from blog posts (scienceblogs.com)**		
destination	absolute	%	destination	absolute	%
scienceblogs.de	2509	52,45	scienceblogs.com	18041	23,40
de.wikipedia.org	3709	7,78	technorati.com	3008	3,90
en.wikipedia.org	882	1,85	blogger.se	2873	3,73
amazon.de	517	1,08	en.wikipedia.org	2430	3,15
flattr.com	393	0,82	delicious.com	2044	2,65
esowatch.com	342	0,72	amazon.com	1088	1,41
arxiv.org	304	0,64	nytimes.com	746	0,97
spiegel.de	238	0,50	researchblogging.org	632	0,82
youtube.com	225	0,47	del.icio.us	625	0,81
twitter.com	202	0,42	ncbi.nlm.nih.gov	519	0,67

Because of our small dataset, we used Kendall's τ for calculating correlation values between Scopus citation counts and bookmark numbers from Mendeley, CiteULike, and BibSonomy. Table 3 shows the correlation values for scienceblogs.de authors; Table 4 displays values for scienceblogs.com authors. For scienceblogs.com, we worked with only 29 authors, because one author had no publications indexed in Scopus. Our findings for all 936 publications from both author sets conform to those of Bar-Ilan et al. (2012); the highest significant correlation is between Mendeley and Scopus at $\tau = 0.483$ (see Table 5). The results indicate that users bookmark and cite in a similar way and that often cited papers are also more likely to be bookmarked. Conversely, social bookmarking systems cover 28% more articles than Scopus, meaning that users of bookmarking systems create via bookmarks a more holistic view of scientific authors and reward more products of scholarly practice (e.g., blog posts).

Table 3. Correlations between the number of citations and bookmarks for 11 scienceblogs.de authors and 198 Publications **Correlation is significant at the 0.01 level (two-tailed)

Kendall's τ	**bookmarks Mendeley**	**bookmarks CiteULike**	**bookmarks BibSonomy**
citations (Scopus)	0.636**	0.397	-0.189

Table 4. Correlations between the number of citations and bookmarks for 29 scienceblogs.com authors and 738 publications. **Correlation is significant at the 0.01 level (two-tailed).

Kendall's τ	bookmarks Mendeley	bookmarks CiteULike	bookmarks BibSonomy
citations (Scopus)	0.463**	0.355**	0.219

Table 5. Correlations between the number of citations and bookmarks for 40 scienceblogs.com/.de authors and 936 publications. **Correlation is significant at the 0.01 level (two-tailed).

Kendall's τ	bookmarks Mendeley	bookmarks CiteULike	bookmarks BibSonomy
citations (Scopus)	0.483**	0.367**	0.107

Conclusion and Outlook

In Web 2.0, citations and references can appear in various formats, and the analysis of citation structures can be applied to different forms of scientific communication on the Web. We have seen that scientists communicate via Twitter and blogs and make use of references in both services. We distinguished between internal and external citations on Twitter, which are interwoven. Slightly differently, we had to distinguish external links from self-citations in blog posts. Furthermore, the visibility of scientific publications in social bookmarking systems was discussed, and different bookmarking systems were compared in terms of coverage. Mendeley is the most popular social bookmarking service and should therefore be fed with publications to make them more visible to the community. Further research should comprise detailed analyses of blog posts', tweets', and scientific articles' content in order to reveal whether bloggers blog and tweet about the same topics that they study professionally. The next step will be to measure the impact of authors on the blogosphere or Twittersphere and determine how indicators should be transferred into the field of scientometrics.

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