Users, Narcissism and Control—Tracking the Impact of Scholarly Publications in the 21st Century

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Abstract

What is my impact? This question has become ever more pressing for all actors in the scientific and scholarly system. The shift to web based publishing has enabled new impact measurement tools that may address the current limitations of peer evaluation and citation analysis. This paper presents the first comprehensive assessment of the limitations and strengths of the most current novel impact monitors. We link this analysis to the literature about alternative impact metrics, such as webometrics and altmetrics. We conclude that a set of interesting novel information tools have emerged and will probably keep emerging in the next few years. They enable a rough indication of publication impact for the individual researcher. At the same time, these tools do not yet produce metrics that can be used for more formal forms of research assessment at either the individual level or at the levels of research groups and universities. We discuss the reasons for this conclusion. We also propose to understand the development of these impact monitors by analyzing the interaction between 'technologies of narcissism', 'technologies of control' and 'users'.

Introduction

What is the scientific and social impact of my research publications? This question has been of interest to scientists and scholars since the inception of modern science 400 years ago. But it was hard to answer. During a large part of the history of modern science, most researchers could not know who was reading their work. The practical applications were also difficult to track, if at all possible. This may now be changing. Scientific and scholarly publishing is being pushed onto the internet (Jankowski, 2009). Scientists and scholars are routinely using web based applications in their research. In virtually all fields of research, digital web based tools have become indispensable (Dutton, Jeffreys & Goldin, 2010). This is not the result of a technological revolution, but rather of an evolutionary interaction between scholarly practices, technologies and research infrastructures (Hine, 2006, 2008; The Virtual Knowledge Studio & *al*., 2008; Wouters, Beaulieu, Scharnhorst & Wyatt, 2012). Scholarship is transforming into a variety of digital networked forms (Borgman, 2007). These changes are affecting the way researchers work, how they communicate their results and insights, and in what forms these results are codified in an archive of knowledge (Bulger & *al*., 2011; Gruzd, Goertzen & Mai, 2011; Williams & *al*., 2009). The emergence of new paradigms of open access is an important example of how these changes have affected the way scholars think about the future of academic publishing (Willinsky, 2006). These developments have created new possibilities and challenges in the evaluation of the quality of research, also at the level of individual researchers and career developments (Wouters & *al*., 2010).

According to information scientist Johan Bollen, we are witnessing ´a Cambrian explosion of metrics´ (Van Noorden, 2010). Over the past 20 years, bibliometrics has shown a ten-fold increase in publications. The field has produced a huge variety of measures and statistics, varying from simple citation and publication counts to sophisticated normalised impact indicators. On top of this, computer scientists have created a host of web based tracking tools which enable every web user to measure the extent to which other web users respond to his activities. Measuring one's impact and influence has never been more popular. Although these tools have not been created to specifically monitor scientific impact, they can be readily applied in the context of research. For example, researchers may enrich their curriculum vitae and publication lists with impact and usage indicators, perhaps linked to discussions and comments from peers in social media and social bookmarking sites. Adoption of this type of use of metrics promises to diversify and enrich the concept of impact and usage of scientific and scholarly research, thus opening the door to the full development of 'influmetrics', a concept already suggested in 1995 by Cronin & Weaver (1995).

This paper aims to contribute to a better understanding of these developments by providing a detailed assessment of the currently available novel tools and methodologies. We do not include an overview of general developments in quantitative science studies and evaluation, such as webometrics, scientometrics, and peer review, since these reviews have already been published (see Moed, 2005; Moed & Glänzel, 2004; Thelwall, 2005; Van Raan, 1988). Instead, we offer a focused analysis of the potential of newly available tools in the context of the literature on established and alternative impact metrics. This assessment is based on the question to what extent these tools can overcome the present limitations of the measurement of publication impact. On this basis, we will survey and analyse the most important current initiatives in innovation of impact measurement and assess their potential value for the future from a research assessment perspective.

Methods and data collection

We performed a comprehensive web search for different online tools, starting with general search engines like Google, selected publications that have already tackled the problem (among other using the user group "Altmetrics" in Mendeley), wikis, discussions with experts, etc. Next, we collected all the relevant information about the tools based on the self-description on the respective websites.

In particular, we collected the following information about each tool:

- availability of metrics about papers;
- availability of metrics about authors;
- availability of metrics about journals;
- availability of metrics about institutes;
- availability of metrics about countries;
- data download and data management options;
- API possibilities;
- availability of citation metrics;
- availability of metrics about (online) readers;
- availability of metrics about downloads and views;
- availability of metrics about bookmarks and tags;

- availability of metrics about comments;
- availability of other logfile metrics;
- availability of data on peer review and discussions;
- transparency of data coverage;
- multidisciplinary of data coverage;
- conditions for access;
- registration procedures (if any);
- options for searching and information filtering;
- options for metrics normalization;
- data standards and data cleansing procedures;
- usability of the web interface.

We analyzed this information on the following criteria:

- Scope of the tool (what type of data are presented, at which levels of aggregation are they presented, what forms of analysis is enabled by the data, etc.)
- Access to the underlying data (can users download the data; create their own analytical frameworks, etc.)
- Transparency of the data (is it clear how the data are collected, are the criteria for the presentation of the data publicly available, etc.)

These three criteria were chosen because we assume that the following properties are positive and desired assets for research assessment tools:

- The tools/sources should allow a certain extensive use for real existing research assessment processes. Thus, they shouldn't be limited only to authors, journals, countries, etc. but be open to use at several aggregation levels and with different analytical possibilities.
- They should allow the download and proper management of data in order to permit the users to create their own frameworks, analysis and approaches.
- Possibilities of normalisation of indicators (by disciplines, document types, etc.) are regarded as very positive (though not absolutely necessary) as they increase the comparability possibilities of the metrics obtained through the tool.

Results

In general all the novel tools analysed present interesting and promising aspects from a research assessment point of view. However, in their current state, due to their limitations and restrictions in use (mostly providing metrics only on the paper and individual levels), it can be claimed that they seem to be more useful for self-assessment than for systematic impact measurements at several levels of aggregation. The main results are summarized in Table 1.

Table 1. Main characteristics of 15 novel impact monitors.

Characteristics	Tools/Sources														
	F1000	Peer Evaluation	Paper Critic	GC	GS	MAS	Arnet-miner	Mendeley	CiteULike	Zotero	Reader meter	Total-impact	Science Card	Plos ONE	SURE2
Metrics for papers	Yes (d)	Yes (a)(d)	Yes (a)(d)	Yes	Yes	Yes	Yes	Yes (a)	Yes (a)(e)	No (c)	Yes	Yes (a)	Yes (a)	Yes	Yes (f)
Metrics for individuals	No	Yes (a)	No	Yes (a)	No	Yes (b)	Yes (b)	Yes (a)	No	No	Yes (a)	No	Yes (a)	No	Yes (f)
Metrics for institutions	No	No	No	No	No	Yes (b)	No	No	No	No	No	No	No	No	Yes
Metrics for countries	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes (a)
Metrics for journals	Yes	No	No	No (f)	No (f)	Yes	Yes (b)	No	No	No	No	No	No	No	No
Data download & management	Yes (b)	No	No	Yes (b)	Yes (b)	Yes (b)	No	Yes (b)	Yes (b)	Yes	No	Yes	No	Yes	Yes (b)
API possibilities	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Citations	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	No
Altmetrics - Readers	No	Yes	No	No	No	No	No	Yes	Yes (b)	No	Yes	Yes	Yes	Yes	No
Altmetrics - Bookmarks/Tags	No	No	No	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Altmetrics - Comments	Yes	Yes	Yes	No	No	No	No	No	Yes	No	No	Yes	Yes	Yes	No
Altmetrics - Downloads, views, etc.	No	Yes	No	No	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes
Altmetrics - Others	No	Yes	Yes	No	No	No	No	No	No	No	No	Yes	Yes	Yes	No
Peer review/Discussion by others	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No	Yes	No
Coverage - Transparency	Yes	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes
Coverage - Multidisciplinary	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes (b)	Yes
Free access	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Registration necessary	Yes	Yes	Yes	Yes	No	No (b)	No (b)	No (b)	Yes	Yes	No	No	No	No	No
Searching/Filtering options	Yes (b)	No (b)	No (b)	Yes (b)	Yes (b)	Yes (b)	Yes (b)	Yes (b)	Yes	Yes	Yes (b)	No	No	No	Yes
Normalisation options	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Data standardisation/cleansing	No	No	No	No	No	Yes (b)	Yes (b)	No	No	No	No	No	Yes	No	Yes
Easy/friendly/intuitive interface	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (b)	No	Yes	Yes

(a) Only items/persons/users included in the system. These are the cases when the tool does not create a universe of publications (e.g. GS, MAS) or personals profiles (e.g. MAS), but depends on the data collected/uploaded by the users.
(b) But with restrictions/limitations. This means that the feature does exist in the functionality/option but can present limitations or difficulties for the given purposes (e.g. downloading big groups of data; calculation of indicators in a systematic way; indicators for several levels of aggregation; mistakes in the data; limited functionalities without registration of the users, etc.).
(c) This is a tool more for data collection & management than for actual metrics.
(d) Some publications don't have any rating/metric. This note refers to the situation when there are publications that although they are in the system they don't have any metric.
(e) No real metrics but tagging, bookmarking, etc. information. These are cases when the data for the publications is not summarised in indicators.
(f) Considering current options in the tool. This means that the functionality is not directly available in the tool, although it is possible with other means (e.g. APIs, ad hoc software, manual collection of data, etc.)

The previous table shows a diverse and relatively complex picture of the different characteristics and possibilities for all the tools surveyed. We find a few patterns quite striking. First of all, most of these tools have developed relatively friendly interfaces (with only two exceptions). Most of them (with only one exception) are also freely available, although most of them require a registration of the user for full access and use of the data. All of them provide metrics at the level of the article, manuscript or book, and also at the individual level; less frequently they allow the calculation of metrics at other levels of analysis (e.g. institutions, journals or countries). Taken together, these characteristics indicate that these tools are mostly attractive for the analysis of individual researchers and scholars. It enables them to freely and quickly see statistical evidence regarding impact, usage, or influence of their publications without too much effort. Without being pejorative, we can conclude that web based academic publishing is producing a variety of 'technologies of narcissism'. With this we mean technologies that allow the researcher to make some sort of limited self-assessment with respect to the response to his/her work. However, this does not mean that these technologies and databases can also legitimately be used as 'technologies of control'. These are technologies that are being used by evaluating and managing actors to subject researchers to forms of research assessment. For impact measurements to be valid as technologies of control, they need to adhere to a far stricter protocol of data quality and indicator reliability and validity.

The main problem is that none of the new tools we reviewed meet crucial requirements for data quality and indicator construction. This prevents them from currently being usable in the context of more formal research evaluation and assessment. As is visible in Table 1, only four of the tools provide a data cleansing and standardisation option, and two of these only in very limited form. This means that these web based tools may create statistics and indicators on incorrect data, without being possible for the user to detect or correct the data properly.

A second relevant requirement is the possibility to normalise indicators (Moed, 2005). This is not an absolute requirement since non-normalised indicators can still provide very useful information. The possibility to normalise, however, does enable a better comparison of impact across different fields. In many evaluation contexts, it is therefore desirable to be able to normalise impact indicators. Table 1 shows that only one tool (Faculty of 1000–F1000) enables some data normalisation (at least at the journal and sub-disciplinary levels).

The third requirement for serious use of a tool in impact measurements relates to the data coverage. In this respect, the results are mixed. A large number of tools have a multidisciplinary coverage, which may enable the consistent use of these tools across fields. However, most tools are not transparent about the data coverage. Only three tools are clear about the way they build up their database. For example, although Google Scholar (GS) is clearly the most popular of the tools discussed, it is not completely clear and documented how GS builds up its database and how the citation frequencies are actually calculated. Applying GS based data in a research assessment context, without considering these limitations and drawbacks, would therefore be unreliable. After all, the researchers evaluated have no means to check either the underlying data or the way the indicators are computed.

The tools have some more relevant limitations. For example, most tools do not provide easy ways for data downloads and data management. Although less severe than the crucial requirements, these limitations also diminish the usability and assessment possibilities of many of these tools.

This does not mean that the tools reviewed cannot play a useful role for scientists and scholars. The reason for this is that the context of use of these measurements is different. A researcher who checks, for example, her citation counts in GS knows everything about the context in which she works. She knows her field, her colleagues and competitors, and the journals or publishers through which she communicates her results and insights. This means that the citation numbers will be interpreted in this context and will not be taken at face value. If the citation data surprise her, she will either learn something about her work that she did not know yet, or attribute it to idiosyncrasies in the way the Google database has been set up or the citation counts are computed. The same holds for all the technologies presented in this report. As technologies of narcissism they may prove to be very useful because they may raise interesting questions for the individual researcher or lay to rest anxieties about one's work. It is quite a different thing to apply the same data and indicators as a technology of control (Beniger, 1986a).

Four arguments for altmetrics

The existing literature about these emerging and alternative tools (e.g. the "Altmetrics manifesto" (Priem, Taraborelli, Groth & Neylon, 2010)) has developed four key arguments in favour of alternative forms of impact measurement by web based tools such as the ones discussed in this paper.

The first argument is diversity of sources and filtering. Because web based publishing and communication has become so diverse, we need an equally diverse set of tools to act upon these traces of communication. The new web-based and altmetrics tools build on their use as information filters to also start measuring some other forms of impact, often defined differently as compared to citation impact.

The second argument is speed. It takes time for traditional publications to pick up citations and citation analysis is only reliable after some time (which varies by fields). The new tools promise an almost instant measurement window. "The speed of altmetrics presents the opportunity to create real-time recommendation and collaborative filtering systems: instead of subscribing to dozens of tables-of-contents, a researcher could get a feed of this week's most significant work in her field. This becomes especially powerful when combined with quick "alt-publications" like blogs or preprint servers, shrinking the communication cycle from years to weeks or days. Faster, broader impact metrics could also play a role in funding and promotion decisions." (Priem & *al*., 2010).

The third argument is openness. Because the data can be collected through APIs (although for limitations on this issue per tool see Table 1), the data coverage is completely transparent to the user. This also holds for the algorithms and code used to calculate the indicators. In this sense, an important advantage discussed in the literature is also the possibility to end the dependency on commercial databases such as Thomson Reuters' Web of Science or Elsevier's Scopus.

The fourth argument is that many web based traces of scientific communication activity can be used to measure aspects of scientific performance that are not captured by citation analysis or peer review. For example, download data could be used to measure actual use of one's work. The number of hyperlinks to one's website might also be an indication of some form of impact.

Although appealing, these four arguments also need to be critically framed and discussed. To start with the fourth argument: is it actually possible to measure more diverse aspects of scientific performance and communication by using novel web based metrics? The answer is "yes, but not yet." It is currently not clear what the numbers might mean. For example, to which dimension of science does the number of tweets relate? And what is the role of blogging in areas such as mathematics or clinical research? Moreover, a statistical framework is lacking to interpret the numbers quantitatively. For example, at what number of tweets should one be impressed? Does this vary by discipline or topic? Can they be cheated or manipulated? The same holds for downloads, usage data, number of incoming hyperlinks, trackbacks in blogs, etc. The advantage of these measures, their diversity, is also their disadvantage: it makes it harder to normalise and contextualise indicators based on these measures. To be sure, we would not want to claim that this is impossible, but it would require a serious ongoing effort to codify the collection of relevant data, their definition, and underlying fundamental research in the characteristics of novel forms of web communications.

The argument of openness has a more political character and is less dependent on technical considerations. It is clear that the system of publications is generally moving towards a higher level of openness, albeit with quite different rates of change in different fields. But it is important to realise that openness has different dimensions (Tatum & Jankowski, 2012). The comparison of the open GS with the commercial Web of Science is informative. Although GS is free while the WoS requires a license, the construction of the dataset and the calculation of indicators are actually more transparent in the WoS than in GS. This has important implications because many web based tools are implicitly based on search engine results. This also holds for many webometric tools (Aguillo, Ortega & Fernández, 2008; Thelwall, Wouters & Fry, 2008; Thelwall, 2005). So although openness is an important asset, it is not always clear that web based tools are a better implementation of this ideal than for-profit information services. In the framework of research evaluation, transparency and consistency of data and indicators may be more important than free availability.

The argument of speed also needs some qualification. Although it may be quite annoying that it takes time for publications to gather citations, this does not mean that faster indicators are necessarily better. For example, the very fast twitter activity tends to be also very superficial. This is exacerbated by the fact that many tweets are generated by computers rather than by humans. It seems plausible to expect that the first waves of tweets about a scientific article may represent an entirely different dimension of science communication than the later wave of perhaps more carefully crafted citations. The evaluation and use of new scientific or scholarly insights simply takes time. Faster may not be better. It is still not clear how fast research evaluation and assessment indicators should be. We cannot discard the possibility that 'Sleeping beauties' (van Raan, 2004) could also play a role in web based communication. Of course, this may be different when the tool is used as an information filter or as a self-appraisal tool. In those cases, speed may count more.

This brings us to the first argument in the literature: diversity. This is a strong argument in favour of the development of new indicators on the basis of new media and activities in science communication. As we indicated, this means that more research work in this area should be encouraged in order to build up a critical mass of validated knowledge which can serve as the basis for new evaluation tools, indicators and information filters.

Users, narcissism and control

These new web impact monitors are being rapidly developed (a good example is the profusion of different tools considered in this paper) and they are continuously improving over time. This continuous development will present ongoing challenges for research assessment in the future (e.g. broader coverage, more citations and publications, other dimensions of 'impact', 'influence' and 'influmetrics', assessment in the humanities, etc.). Although in their current state of development they are inadequate for a systematic and extensive use (i.e. with the same research assessment purposes as Web of Science or Scopus), this could change in the future. Solving some of the main issues described in this paper would clearly reinforce the role of web based impact monitors in research assessment.

Although the emphasis in this paper has been on the empirical analysis of the strengths and weaknesses of novel impact monitors, it is also important to understand the larger ecology in which these tools develop. An important driver of innovation in this area might be the demand in the research community for easy tools to estimate the impact of individual researchers. We call tools used in this way "technologies of narcissism." Of course, this "narcissism" is not a spontaneously emerged personality property. Rather, it will also be driven by the way researchers are asked to account for their work. We call impact monitors used in more formal research assessments "technologies of control," inspired by Beniger's analysis of "the control society" (Beniger, 1986b). A third perspective on impact monitors is the use of these tools as information filters, for example to select the most influential journal articles to get acquainted with a particular new field. We expect that the future configurations of impact measurements will be determined by the interactions between technologies of control, of narcissism, and of information filtering. This may mean that we will not witness an unambiguous development towards more openness, for example. This theoretical framework will also enable us to better understand the pragmatic and normative limits of assessment systems as such.

From a conceptual point of view, the main limitations and problems observed for traditional bibliometrics at the individual level (Costas, van Leeuwen & Bordons, 2010) are also relevant in the case of these new web-based tools (e.g. statistical limitations and sensitivity to outliers, lower reliability of indicators at this level, problems in the comparability of researchers, possibilities of manipulation of indicators, etc.). In addition, the introduction of inappropriate research assessment methodologies and especially the misuse of the new metrics may result in unintended modifications of the behaviour of scientists (e.g. changes in their selection of research topics, in their publication strategies, etc.). Therefore it is important to consider the incentives that are introduced by these new tools and indicators. New impact monitors will introduce new strategic behaviour of researchers as well as ways for manipulation of these monitors. These should be studied in tune with the development of these monitors.

In line with the previous, the current users of these new web based tools and altmetrics must use them with great care and caution, especially due to this individual level focus. It is also important that the developers of these tools realise that being mainly providers of indicators for individuals could 'trivialise' their image among scholars and research managers as only providers of 'technologies of narcissism', thus jeopardising their real potential value as strong and standardised assessment tools. For all this, their evolution and transformation from 'technologies of narcissism' to 'technologies of control' may strongly contribute to their broader acceptance among the scientific community.

Further research

In the light of all the previous, there are various challenging lines of research that should be developed in the field of altmetrics and web tools for the measurement of other types of influence of scientific publications. Although there are several, most of these lines can be summarised in three main topics:

Conceptualisation of the new web metrics and altmetrics

Creating a sound conceptual framework for all these tools and metrics is probably the most important line of research. It should be the basis for the validation of the new indicators developed. Among the main research questions that should be answered are: What do these new metrics measure? What dimensions of the scientific communication process and impact do they represent? How do these indicators relate among them? Can some of them be replaced or complemented by others? Are some of them predictors of some of the others? Are there differences by fields?

Standardisation of the existing tools and data

This would be a line of a more methodological nature. Aspects related to the proper availability and formatting of information, the detection of problems and limitations regarding the tools and data, as well as the establishment of general frameworks for analysis and benchmarking would be essential (Weller & Puschmann, 2011). For example, the determination of the number of different users, readers, bloggers, tweeters, etc., and their origin (country, fields, age, etc.) would be necessary in order to be able to compare and contextualise the indicators. The detection of potential ways of manipulation as well as the classification and proper normalisation of all the indicators are topics that will deserve much more attention as the available tools will continue their development and growth.

Production, normalisation and use of the new metrics

Research on how the new indicators should be calculated and normalised, their mathematical and statistical properties, would be topics of high interest comparable to how these currently are in the field of bibliometrics. The proper combination of all these new tools with other more traditional measures to obtain meaningful and valid analytical information would be also a topic of great interest. Since ‘perfect’ tools for evaluating the quality of research will not be found, important questions that must be addressed would be: How do we properly use the available methods and metrics? How do we interpret the indicators produced? How do we prevent these metrics, rankings and evaluations to be seen as ‘the truth and nothing but the truth’, and to be used uncritically as a base for important political, policy and career decisions?

To summarise, a concerted research programme in the dynamics, properties, and potential use of new web based metrics which relates these new measures to the already established indicators of publication impact may contribute to the development of more useful tools for the scientific and scholarly community.

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References

Aguillo, I. F., Ortega, J.L. & Fernández, M. (2008). Webometric Ranking of World Universities: Introduction, Methodology, and Future Developments. *Higher Education in Europe*, 33 (2-3), 233-244. doi:10.1080/03797720802254031

Beniger, J.R. (1986a). *The Control Revolution. Technological and Economic Origins of the Information Society*. Cambridge, Mass. and London: Harvard University Press.

Beniger, J.R. (1986b). *The Control Revolution. Technological and Economic Origins of the Information Society*. Cambridge, Mass. and London: Harvard University Press.

Borgman, C.L. (2007). *Scholarship in the Digital Age: Information, Infrastructure, and the Internet*. The MIT Press. Retrieved from http://www.amazon.com/dp/0262026198

Bulger, M., Meyer, E.T., Flor, G. de la, Terras, M., Wyatt, S., Jirotka, M., Eccles, K. & *al*. (2011). *Reinventing Research? Information Practices in the Humanities*. *Network* (pp. 1-83). Retrieved from http://www.rin.ac.uk/our-work/using-and-accessing-information-resources/information-use-case-studies-humanities

Costas, R., van Leeuwen, T.N. & Bordons, M. (2010). A Bibliometric Classificatory Approach for the Study and Assessment of Research Performance at the Individual Level: The Effects of Age on Productivity and Impact. *Journal of the American Society for Information Science and Technology*, 61 (8), 1564-1581.

Cronin, B. & Weaver, S. (1995). The Praxis of Acknowledgement: From Bibliometrics to Influmetrics. *Revista Española de Documentación Científica*, 18 (2), 172-177. Retrieved from http://www.libsearch.com/view/1144111

Dutton, W.H., Jeffreys, P.W. & Goldin, I. (2010). *World Wide Research: Reshaping the Sciences and Humanities*. William H. Dutton & P.W. Jeffreys (Eds.) (New., p. 408). Cambridge, Mass.: The MIT Press. Retrieved from http://www.amazon.com/dp/0262513730

Gruzd, A., Goertzen, M. & Mai, P. (2011). *Survey Research Highlights: Trends in Scholarly Communication and Knowledge Dissemination in the Age of Online Social Media*. *Knowledge Creation Diffusion Utilization*. Halifax, Canada.

Hine, C. (2006). *New Infrastructures for Knowledge Production. Understanding e-science*. Hershey: Information Science Publishing.

Hine, C. (2008). *Systematics as Cyberscience: Computers, Change, and Continuity in Science*. Cambridge, Mass.: MIT Press.

Jankowski, N. (Ed.). (2009). *E-Research: Transformation in Scholarly Practice (Hardback) - Routledge*. Routledge. Retrieved from http://www.routledge.com/books/details/9780415990288/

Moed, H.F. (2005). *Citation Analysis in Research Evaluation*, vol. 9. Dordrecht: Springer.

Moed, H.F. & Glänzel, W. (2004). *Handbook of Quantitative Science and Technology Research: the Use of Publication and Patent Statistics in Studies of S&T Systems*. Dordrecht etc.: Kluwer Academic Publishers.

Priem, J., Taraborelli, D., Groth, P. & Neylon, C. (2010). Altmetrics: A Manifesto–altmetrics.org. Retrieved January 8, 2012, from http://altmetrics.org/manifesto/

Tatum, C. & Jankowski, N. (2012). Beyond Open Access: A Framework for Openness in Scholarly Communication. In Paul Wouters, A. Beaulieu, A. Scharnhorst & S. Wyatt (Eds.), *Virtual Knowledge*. Cambridge, Mass. and London: MIT Press.

Thelwall, M. (2005). *Link Analysis: An Information Science Approach*. San Diego: Academic Press.

Thelwall, M., Wouters, P. & Fry, J. (2008). Information-Centered Research for Large-Scale Analyses of New Information Sources. *Journal of the American Society for Information Science and Technology*, 59 (9), 1523-1527.

Van Noorden, R. (2010). Metrics: A Profusion of Measures. *Nature*, *465*(7300), 864-6. Nature Publishing Group. Retrieved from http://www.nature.com/news/2010/100616/full/465864a.html

Van Raan, A. (Ed.). (1988). *Handbook of Quantitative Studies of Science and Technology*. Amsterdam: Elsevier Science Publishers.

Van Raan, A.F.J. (2004). Sleeping Beauties in Science. *Scientometrics*, 59 (3), 461-466.

Weller, K. & Puschmann, C. (2011). Twitter for Scientific Communication: How Can Citations/References be Identified and Measured? *Proceedings of the ACM WebSci'11*. Retrieved from http://journal.webscience.org/500/2/Fig1.png

Williams, R., Pryor, G., Bruce, A., Macdonald, S., Marsden, W., Calvert, J., Dozier, M. & *al.* (2009). *Patterns of Information Use and Exchange Case Studies of Researchers in the Life Sciences* (pp. 1-56). Retrieved from http://www.rin.ac.uk/our-work/using-and-accessing-information-resources/patterns-information-use-and-exchange-case-studie

Willinsky, J. (2006). *The Access Principle: The Case for Open Access to Research and Scholarship*. Cambridge, Mass.: The MIT Press. Retrieved from http://www.amazon.com/dp/0262232421

Wouters, P., Vann, K., Scharnhorst, A., Ratto, M., Hellsten, I., Fry, J. & *al*. (2008). Messy Shapes of Knowledge-STS Explores Informatization, New Media, and Academic Work. In Edward J. Hackett, Olga Amsterdamska, Michael Lynch & Judy Wajcman (Eds). *The Handbook of Science and Technology Studies* (pp. 319-352). Cambridge, Mass.: MIT Press.

Wouters, P., Bar-Ilan, J., Thelwall, M., Aguillo, I. F., Must, Ü., Havemann, F., Kretschmer, H. & *al*. (2010). *Academic Careers Understood through Measurement and Norms (ACUMEN)* (pp. 1-39).

Wouters, P., Beaulieu, A., Scharnhorst, A. & Wyatt, S. (2012). *Virtual Knowledge*. Cambridge, Mass. and London: The MIT Press.

Wouters, P. & Costas, R. (2012). *Users, Narcissism and Control–Tracking the Impact of Scholarly Publications in the 21 Century* (pp. 1-50). Utrecht.