Feature Analysis and Impact Analysis of High-Altmetrics Papers (Postprint)

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Abstract

[Objective/Significance] Investigating the principal characteristics of Altmetrics indicators, their correlation with traditional bibliometric indicators, and their temporal evolution; furthermore, comprehensively evaluating the social and academic impact of scholarly papers based on Altmetrics indicators is essential for the development and refinement of the Altmetrics measurement system. [Methods/Process] Using the Altmetric Top 100 papers from 2014-2016 as a sample, this study conducts statistical analysis on the source journals, disciplinary distribution, access modes, geographical distribution of authors, and institutional distribution of high Altmetrics indicator papers for each year, and discusses their social impact. Concurrently, it analyzes the correlation between papers' Altmetric scores and their citation frequencies in Web of Science to investigate the dynamic evolution of this correlation over time. [Results/Conclusion] The results demonstrate that high Altmetrics indicator papers primarily originate from high-impact-factor journals, with disciplines mainly concentrated in health, medical, and biological sciences. Authors of these papers predominantly come from high-level research institutions in developed European and American countries, and the proportion of open and free access among high Altmetrics indicator papers increases annually. Altmetric scores can quantitatively reflect the degree of public attention received by scholarly papers on social and news media, thereby manifesting the social impact of scholarly papers to a certain extent. A positive correlation exists between the Altmetric scores of high Altmetrics indicator papers and their citation frequencies, indicating that high Altmetrics indicator papers simultaneously possess relatively high academic impact.

Full Text

Preamble

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Analysis of Features and Influence of Papers with High Altmetrics Scores

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Abstract

[**Purpose/Significance**] Investigating the main features of Altmetrics indicators and their correlation with traditional bibliometric indicators, along with their evolution over time, is crucial for the development and improvement of the Altmetrics measurement system. A comprehensive evaluation of both the social and academic influence of scholarly papers based on Altmetrics indicators is essential. [**Method/Process**] This study takes the Altmetric Top 100 papers from 2014-2016 as samples, conducting statistical analysis of their source journals, disciplinary distribution, access methods, and geographic and institutional distribution of authors, while discussing the social influence of these papers. Simultaneously, we analyze the correlation between Altmetric scores and citation frequencies from Web of Science, examining the dynamic evolution of this correlation over time. [**Result/Conclusion**] The results show that high Altmetrics papers primarily originate from high-impact-factor journals, with disciplines concentrated in medical & health and biological sciences. Authors are mainly from high-level research institutions in developed European and American countries, and the proportion of open-access and free-access papers among high Altmetrics papers increases annually. Altmetric scores can quantitatively reflect the degree of public attention that academic papers receive on social and news media, thereby demonstrating their social influence to some extent. There is a positive correlation between Altmetric scores and citation frequencies for high Altmetrics papers, indicating that these papers also possess significant academic influence.

Classification Number: G203
Keywords: Altmetrics; Feature Analysis; Academic Influence; Social Influence

Introduction

In recent years, with the widespread use of social platforms on the Internet, a novel metric called Altmetrics has emerged. Altmetrics (derived from "alternative metrics") is a paper impact measurement method that relies on big data from the Internet, reflecting the social and academic influence of papers through recommendations, collections, mentions, and shares on online platforms or social networks. Altmetrics has been translated as "selective metrics," "alternative metrics," or "supplementary metrics," representing a form of scientometrics based on the Web 2.0 environment (Scientometrics 2.0). Early studies have shown that traditional metrics based on citation analysis, peer review, and journal impact factors suffer from drawbacks such as time lag, one-sided influence, and the "Matthew effect" in citations. Unlike these traditional methods, Altmetrics can track the real-time, efficient dissemination of academic achievements,

accurately measure discussions and evaluations from different user groups (including researchers and the general public), and thus diversely measure both the social and academic influence of achievements. Therefore, Altmetrics features real-time data updates, diversified processing objects, and broad public participation. Altmetrics not only expands the breadth of paper evaluation, making it more comprehensive, specific, and objective, but also deepens the depth of evaluation to include deeper social impact.

Since its proposal in 2010, Altmetrics has gained widespread attention and application due to its real-time, efficient, and comprehensive feedback and evaluation mechanisms. Multiple publishers and institutions, including Springer Nature, the American Association for the Advancement of Science (AAAS), Elsevier, the National Academy of Sciences (NAS), Wiley, the American Chemical Society (ACS), Taylor & Francis, and others, have adopted Altmetrics indicators to measure the attention their published papers receive on social networks, assessing academic influence from the perspective of different groups' attention to papers. Currently, several websites or institutions provide Altmetrics indicators for individual papers, with three prominent and commonly used platforms being Altmetric.com (www.altmetric.com), Plum Analytics (www.plumanalytics.com), and ImpactStory (www.impactstory.org). No unified standard has yet been formed for calculating Altmetrics indicators. The algorithm proposed by Altmetric.com has been widely used and recognized, representing the most mature Altmetrics algorithm to date. Altmetric.com collects online attention data (such as comments, tweets, shares, and reposts) for a paper from mainstream news media, social networking sites (including blogs, Twitter, Facebook, Sina Weibo, LinkedIn, Google+, Pinterest, Reddit), reference management sites (including Mendeley, CiteULike, Wikipedia, OpenSyllabus, Policy Documents, F1000), and multimedia (YouTube). It then applies specific weighted summation to these different data types to aggregate a metric known as the Altmetric score, which quantitatively characterizes a paper's influence based on social networks. The influence reflected by Altmetrics includes not only academic influence—primarily manifested through researchers using social platforms to manage literature and conduct academic exchanges and discussions, enabling rapid dissemination and citation of papers—but also social influence, mainly reflected in the understanding and popularization of academic achievements among the general public. By utilizing diverse data resources in the social network environment and applying specific combined measurement, Altmetrics provides a timely and comprehensive metric for evaluating the social and academic influence of papers.

Research Progress in Altmetrics Measurement

With the rise of Altmetrics, many bibliometrics experts at home and abroad have conducted in-depth research on Altmetrics indicators, primarily exploring the relationship between these indicators and other metrics, identifying the advantages and disadvantages of Altmetrics, and proposing the construction of corresponding academic evaluation systems and related measurement stan-

dards. G. Eysenbach analyzed the correlation between Twitter counts and citation frequencies for 55 papers in the *Journal of Medical Internet Research*, suggesting that the number of tweets in the first three days after publication can predict whether a paper will become highly cited. X. Li et al. used 1,613 papers published in *Nature* and *Science* in 2007 as samples and found that attention on CiteULike and Mendeley positively correlated with citation counts in Web of Science (WoS). E. Mohammadi and M. Thelwall studied the relationship between Mendeley readership and citation frequencies for papers in the social sciences and humanities, noting that Mendeley attention can indicate paper influence earlier and more effectively than citation counts. R. Costas et al. analyzed Altmetrics indicators for 700,000 papers across different disciplines, finding a weak positive correlation between Altmetrics indicators and citation frequencies. Song Liping et al. analyzed 1,033 papers in psychology and ecology, showing that peer review data from Mendeley and F1000 had low correlation with citation frequencies in WoS. You Qingbin and Tang Shanhong summarized five characteristics of Altmetrics measurement and analyzed papers in PLOS and F1000 social networks, examining the correlation between these metrics and citation indicators. Zhao Rongying et al. used 279 papers in Chinese language and literature as samples, finding that Altmetrics indicators and traditional citation metrics show both consistency and differences in evaluation results, with Altmetrics indicators focusing more on measuring social influence and attention but serving as a supplement to traditional citation metrics. Wang Rui et al. compared Altmetric scores and WoS citation frequencies for 273 sample papers, concluding that the two different indicators reflect different attention directions from readers and media, and that high Altmetrics scores can to some extent be seen as an indicator of future high citations. Qiu Junping et al. introduced Altmetrics functions for different institutional repository platforms, noting that Altmetrics can compensate for deficiencies in traditional measurement methods and institutional repository quality control. Guo Fei et al. studied the correlation between Altmetric scores of hot papers and their citation counts in WoS, analyzing the diversity of dissemination channels, media distribution, and social media impact. The results showed that hot papers reach peak dissemination on Twitter 10-30 days after publication, with main influencing factors including the novelty of academic content, open-access availability, and marketing approaches. Kuang Denghui conducted statistical analysis of journal distribution, author groups, and media dissemination channels for 2015 Altmetrics hot papers, showing these papers have high social influence and attention, while noting low visibility for Chinese journal papers. Wan Hao et al. conducted quantitative analysis of 120 empirical studies, comparing the roles of traditional bibliometrics and Altmetrics in research evaluation, concluding that Altmetrics is more open and diverse in form for influence evaluation. Since 2017, some researchers have systematically studied the correlation between Altmetrics indicators and traditional metrics (including citation counts, journal impact factors, and field-normalized citations), considering the impact of indicator types and user categories on correlations. Based on these analyses, they constructed comprehensive influence evaluation models

with multi-dimensional indicators for different disciplines.

Recent research on Altmetrics measurement has become a hot topic in bibliometrics. Earlier studies focused on introducing the concept, tools, connotations, and characteristics of Altmetrics measurement. Recent empirical studies have primarily explored the relationship between Altmetrics indicators and traditional bibliometric indicators. However, these empirical studies are often limited to analyzing relatively single-year or single-discipline data, lacking examination from a temporal evolution perspective and comprehensive evaluation of both academic and social influence of papers based on Altmetrics indicators. Considering that Altmetrics indicators have better timeliness than traditional bibliometric indicators, studying the characteristics of Altmetrics indicators and their correlation with citation indicators over time, along with comprehensive influence evaluation, is particularly important. This paper uses the top 100 papers by Altmetric score from 2014-2016 as samples, analyzing their source journals, disciplinary distribution, access methods, author geography, and institutional distribution, as well as the correlation between Altmetric scores and traditional citation indicators and their dynamic evolution over time. This demonstrates how Altmetrics measurement evaluates the social and academic influence of journal papers, explores the main features and functions of Altmetrics measurement and their dynamic evolution, and provides guidance for deeper understanding and use of Altmetrics measurement.

Data Collection for High Altmetrics Papers

Since 2014, Altmetric.com has annually published the top 100 academic papers with the highest Altmetric scores from the previous year—Altmetric Top 100—on its website. The published information includes these papers' Altmetric scores, source journals, disciplinary distribution, author lists, access methods, and the degree of attention from different media (such as comment, tweet, share, and repost counts) used to calculate the Altmetric scores. This study selects the 100 high Altmetrics papers published annually from 2014-2016 as data samples to analyze the characteristics of high Altmetrics papers and evaluate their social influence. Simultaneously, we use the WoS database to count citation frequencies for these 300 academic papers and record whether they are highly cited or hot papers, thereby analyzing the relationship between Altmetric scores and citation frequencies and demonstrating the academic influence of high Altmetrics papers. The high Altmetrics papers and related data (including Altmetric scores, source journals, disciplinary distribution, author lists, access methods, and media attention) come from Altmetric.com's annual statistics, while corresponding citation frequencies and whether they are highly cited or hot papers come from the WoS database, with citation queries and collection ending on July 31, 2017.

Main Features of High Altmetrics Papers

The algorithm proposed by Altmetric.com is a relatively mature and widely recognized algorithm in Altmetrics measurement. The Altmetric score quantitatively represents the social attention a paper receives after publication, reflecting its social influence. Recent studies have shown that Altmetric scores can serve as an early potential indicator of academic quality. This section analyzes the main features of Altmetric Top 100 papers over the past three years and examines their social and academic influence.

4.1 Main Features of High Altmetrics Papers

Table 1 lists the distribution of source journals for Altmetric Top 100 papers from 2014-2016. The table shows that over 30% of Altmetric Top 100 papers each year originate from *Nature*, *Science*, and their sub-journals, with nearly 10-15% from *Proceedings of the National Academy of Sciences* (PNAS) and *Public Library of Science* (PLOS ONE), and 15-25% from three authoritative journals: *Journal of the American Medical Association* (JAMA), *New England Journal of Medicine*, and *The Lancet*. Among these journals, *Nature*, *Science*, PNAS, and PLOS ONE are comprehensive natural science journals, while JAMA, *New England Journal of Medicine*, and *The Lancet* are medical and life sciences journals. Notably, these are all authoritative journals in natural sciences with high impact factors, suggesting that high Altmetric scores align with high-impact source journals. Over the three years, *Nature* consistently contributed the most Altmetric Top 100 papers, indicating its most significant paper quality and influence. This is also closely related to *Nature*'s unique news release service. After each issue is published online, *Nature* promptly notifies relevant institutions for news coverage, highlights some achievements in its "News & Views" section, and discusses related hot topics. These news services generate global media attention for research findings.

Table 2 shows the access method distribution for Altmetric Top 100 papers from 2014-2016. Each year, over 50% of papers require paid access, nearly 30% are open access, and the remainder are freely accessible (primarily from preprint repositories). Notably, as open access and free access continue to develop, an increasing proportion of journal papers become accessible to the general public, enabling broader dissemination and attention from various online media. The increasing proportion of open and free access among Altmetric Top 100 papers demonstrates that such access methods effectively promote paper dissemination, making them more likely to attract substantial attention across media and networks, thereby enhancing their Altmetric scores.

Table 3 presents the disciplinary distribution of Altmetric Top 100 papers from 2014-2016. Papers in medical and health fields account for the largest share, exceeding 40% annually, followed by biological sciences at 15-20%. Human society research, physical sciences, psychology and reproducibility research, and earth and environmental sciences each account for less than 10%. History, ar-

chaeology, information, and computer science papers constitute about 5%, while materials science, engineering, and chemical science papers have the lowest proportion at only 1-2%. These data indicate that high Altmetrics papers concentrate in medical, health, and biological sciences, demonstrating public interest in biomedical research. High Altmetric scores also reflect extensive social media dissemination and strong social influence. During dissemination, these papers may stimulate citations from other researchers, thereby enhancing academic influence. Fields like materials science, engineering, and chemical science, due to their high specialization and theoretical nature, attract less public attention and social media dissemination, resulting in weaker social impact. In terms of research topics, the public primarily focuses on findings closely related to daily life or major scientific discoveries, sometimes including interesting research titles. For example, the 2016 paper on LIGO's first detection of gravitational waves ranked third among Altmetric Top 100 papers that year, while the paper on AI Go program AlphaGo defeating human professional players ranked ninth. The top-ranked Altmetric Top 100 paper in 2016 was an article by former U.S. President Barack Obama on the current progress and future prospects of U.S. healthcare reform.

Tables 4 and 5 show the nationality distribution of authors and the institutional distribution of authors from the U.S., U.K., and Germany for Altmetric Top 100 papers from 2014-2016. Table 4 reveals that U.S. authors consistently contribute the most papers each year, followed by the U.K. and Germany, then Australia, France, Canada, China, Japan, and Russia. The U.S. dominance is related not only to high research levels and novel research topics but also to its developed social media landscape, as the primary social media and multimedia platforms (Twitter, Facebook, LinkedIn, Google+, Pinterest, Reddit, YouTube) from which Altmetrics collects data all originate from the U.S. Although China now leads the world in paper publication volume and ranks second in citations, its contribution to high Altmetrics papers lags far behind developed countries like the U.S., U.K., and Germany. Key reasons include: first, China's research level still has gaps compared to developed European and American countries; second, Altmetrics does not include domestic Chinese social news media in its data collection scope, and Chinese scholars have limited sharing and dissemination of research findings on international mainstream news media and social websites, resulting in insufficient visibility for Chinese research papers on international social platforms. Table 5 shows that high Altmetrics papers from the U.S., U.K., and Germany primarily come from top international universities and research institutes in these countries, indicating that these institutions' research levels are internationally leading and thus produce more high Altmetrics papers. Notably, over 60% of Altmetric Top 100 papers each year involve international collaboration, with U.S.-Europe cooperation accounting for the majority. This demonstrates that international exchange and cooperation among European and American scholars amplify their research advantages, yielding more high Altmetrics papers. Given this situation, Chinese scholars should strive to improve their research level while increasing international promotion, pushing excellent aca-

demic papers to foreign mainstream media and commonly used social media, actively sharing results with foreign scholars online, and strengthening international exchange and cooperation with scientifically advanced countries like Europe and the U.S.

4.2 Social Influence of High Altmetrics Papers

Altmetric scores quantitatively reflect the degree of public attention academic papers receive on social and news media. News media disseminate information relatively uniformly through reporting or commentary, while social media offer more diverse dissemination methods including likes, reposts, comments, shares, and pushes. During the attention process, scientific knowledge in papers spreads, becoming understood, familiarized, or discussed by the public, or applied by non-academic organizations, thereby serving the public and society and demonstrating papers' social influence. Previous studies classified paper followers, showing over 70% are ordinary citizens and 30% are research personnel with relevant backgrounds. Public participation enables broader dissemination of academic papers and research findings. Notably, research results with high practical value and relevance to daily life spread more easily through social media, becoming familiar to and discussed by the public, directly reflecting the social impact of scientific achievements. Public participation in sharing and discussing academic papers helps the public understand and master more in-depth scientific knowledge, promotes scientific literacy, and positively drives science popularization in society. Additionally, public participation in discussing academic achievements provides oversight for the scientific community. The openness of social and news media allows academic achievements to receive joint supervision from academia and society. During this attention process, excellent research findings are widely disseminated, while erroneous or unethical achievements are condemned and excluded. Beyond public participation, scholars with research backgrounds provide more professional evaluation and discussion, facilitating the examination, improvement, and enhancement of academic achievements.

Two high Altmetrics papers illustrate their social influence. The 2016 paper on LIGO's first detection of gravitational waves (ranked third) and the paper on AlphaGo defeating human professional Go players (ranked ninth) were widely disseminated in 2016, receiving 4,584 and 2,013 retweets on Twitter respectively one month after publication, with Altmetric scores reaching 4,660 and 3,047. Extensive news and social media coverage helped the public understand gravitational waves and artificial intelligence. Meanwhile, in the research field, studies involving gravitational waves and AI became frontier hotspots, receiving tremendous promotion. In 2017, LIGO won the Nobel Prize in Physics, and AI experienced rapid development in multiple interdisciplinary fields.

4.3 Academic Influence of High Altmetrics Papers

Figure 1 [Figure 1: see original paper] presents the correlation analysis between Altmetric scores and citation frequencies for Altmetric Top 100 papers from 2014-2016. Citation counts come from the WoS database, with data collection ending in July 2017. Pearson correlation analysis of Altmetric scores and citation frequencies yields correlation coefficients of r = -0.021, r = 0.229, and r = 0.271 for 2014, 2015, and 2016 respectively. The data show that except for 2014, Altmetric scores positively correlate with citation frequencies in 2015 and 2016, consistent with Wang Rui et al.'s findings. The negative correlation in 2014 occurred because Altmetrics-based ranking was first introduced that year without widespread academic attention. After 2014, as Altmetrics gained academic recognition, the ranking data published in 2015 and 2016 led to massive citations of these high Altmetrics papers in the short term, making the correlation more pronounced. Wide dissemination of high Altmetrics papers on social networks and media influences citation frequencies to some extent, helping increase academic impact. Notably, the correlation coefficient between Altmetric scores and citation frequencies for high Altmetrics papers has gradually increased year by year since 2014, indicating that the correlation between Altmetrics and traditional bibliometric indicators evolves over time.

Figure 2 [Figure 2: see original paper] shows the citation frequency distribution for Altmetric Top 100 papers from 2014-2016. Approximately 1-2% of papers receive over 500 citations in the short term, 10-15% receive 200-500 citations, most receive 10-200 citations, and about 10% receive fewer than 10 citations. Low citation frequencies occur because some papers receive extensive media and social network coverage upon publication, resulting in high Altmetric scores, but after scrutiny, controversial or erroneous findings lead to low citations. This reveals a limitation of Altmetrics: its quantitative nature can be influenced or manipulated by factors such as media or social network bias. Statistics show that average citation frequencies for high Altmetrics papers from 2014-2016 are 148, 115, and 79 respectively, all higher than the annual average citation frequency for papers in the WoS database. The decreasing average citation frequency over the years reflects time accumulation effects (e.g., 2014 papers' citations were counted from 2015-2017).

Table 6 presents the citation evaluation of Altmetric Top 100 papers from 2014-2016. Highly cited papers and hot papers are academic evaluations based on the WoS database. Highly cited papers are those ranked in the top 1% of citation frequency for their publication year, while hot papers are in the top 0.1%. The data show that approximately 50% of high Altmetrics papers each year are highly cited papers, with the proportion of hot papers increasing from 7% to 26% since 2015. These results demonstrate that Altmetrics indicators can reflect academic quality to some extent, and high Altmetrics papers simultaneously possess significant academic influence, primarily manifested through high citation frequencies.

Conclusion

Altmetrics is a novel scientometric method that has emerged in recent years based on the Web 2.0 environment. Unlike traditional bibliometric methods, it utilizes diverse data resources in the social network environment through specific combined measurement to evaluate the academic and social influence of academic papers. Altmetrics expands the objects of measurement and evaluation beyond citation behaviors among journal papers to include online acquisition, dissemination, and usage behaviors of academic achievements on social networks. This paper statistically analyzed the source journals, disciplinary distribution, access methods, author geography, and institutional distribution of Altmetric Top 100 papers from 2014-2016, and examined the correlation between Altmetric scores and citation frequencies along with their dynamic evolution over time. The analysis shows that Altmetrics indicators can reflect the social influence of academic papers while also capturing academic influence, and that the correlation between Altmetrics and traditional citation indicators evolves over time. Altmetrics provides new opportunities for transforming online academic exchange and evaluation systems.

However, Altmetrics measurement still has limitations. The quantitative nature of Altmetrics indicators can be affected by biases in public Internet usage, scholars' awareness of Altmetrics measurement remains low, and some Altmetrics indicators are driven by commercial behavior. Therefore, Altmetrics methods and theories need further improvement. With increasing online research activity, Altmetrics indicators will become a powerful supplement to traditional research evaluation. Introducing Altmetrics indicators into bibliometrics as an important supplement and extension for evaluating academic influence will help build a comprehensive academic achievement evaluation system. China's research and application of Altmetrics measurement have lagged behind developed European and American countries in recent years. Given the rapid development of Altmetrics measurement and its important future role in bibliometrics, China urgently needs to strengthen research and application in this area. Meanwhile, to better adapt to Altmetrics measurement, Chinese scholars should enhance international promotion, push high-quality academic papers to foreign mainstream social media, actively share results with foreign scholars through online platforms, and thereby enhance the academic influence of Chinese academic papers.

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Analysis on Features and Influence of Papers with High Altmetrics Scores

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Abstract: [Purpose/significance] Investigating the main features of Altmetrics indicators and their correlation with conventional bibliometric indicators, the variation of features and correlation with time, and its comprehensive evaluation on both social and academic influences of academic papers are crucial for both development and improvement of Altmetrics. [Method/process] In this paper, we took Altmetric Top 100 papers from 2014 to 2016 as samples, analyzed their source journal, discipline category, access method and authors' affiliation, and further discussed their social influence. At the same time, we investigated the relationship between Altmetric scores of these Altmetric Top 100 papers and their citation counts from Web of Science, and the variation of such relationship with the time. [Result/conclusion] The results showed that most papers with high Altmetrics scores are from high-profile journals with high impact factors, and are in fields of medical & health sciences and biological sciences. Most authors of these papers with high Altmetrics scores are from the institutes with high research level in United States of America, United Kingdom and Germany. The fraction of free-accessed papers in the papers with high Altmetrics scores increases annually. Altmetric score can quantitatively reflect the amount of attention that the social medias pay to the academic papers, which to some extent indicates the social influence of these academic papers. Altmetric scores of Altmetric Top 100 papers positively correlate their citation counts, implying that these papers with high Altmetrics scores have significant academic influence.

Keywords: altmetrics; feature analysis; academic influence; social influence

Note: Figure translations are in progress. See original paper for figures.