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Altmetrics of Highly Cited Research Papers in Social Science

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ABSTRACT

The purpose of this study is to examine the altmetrics of academic papers highly cited in the social sciences and to assess whether the altmetrics show any correlation with the citations and open access status. To accomplish this goal, 638 highly cited articles from SCOPUS were extracted and PlumX metrics were used to measure the altmetrics (views, readers, blogs, Wikis, and Tweets). Then, the relationship among altmetrics, citation rates, and open access status was analyzed through Spearman correlation analysis and the Mann–Whitney test. In addition, with corresponding analysis, this study identified and visualized the differences in altmetrics between 10 social science sub-disciplines. As a result, the papers in the social sciences have greater than one altmetrics presence in greater than 30% of all altmetrics sources. In detail, greater than 90% of the papers had one or more readers in Mendeley, and 50% of the papers had one or more references in Wiki. There was also a strong correlation between the numbers of citations and readers, and open access papers showed a higher altmetrics presence than those that were closed. In terms of differences between disciplines, many psychology articles were registered as a reference on Wiki; many articles in the fields of humanity, society, and politics were drawn to popular discussions through Tweets; and the education field had the highest number of Mendeley readers. This study traced the social influence of highly cited papers in the social sciences that had not been understood before and then statistically interpreted the differences in social impact among the 10 social science disciplines.

KEYWORDS

Altmetrics; citation;
Mendeley; open access;
social science

Introduction

The communication channels of academic researchers are diversifying. Those who published research results through scholarly journals during the past are using blogs and social media and publishing and distributing scholarly research results through open access journals and online repositories. In addition, researchers are using online reference management software and professional networks during the research process. Thus, researchers leave a variety of log data about information usage online during their academic activities. By tracking these traces, we were able to grasp the social influence of the research, which cannot be understood by referring to existing citations method alone. Citation information that has been used for a long time in the field of quantitative bibliographies cannot measure the impact on non-authors such as practitioners, clinicians, educators, and students and their practical activity, learning, and education. Therefore, there is a need to develop tools that can measure not only how much they are cited by

subsequent studies but also how they are affecting society as a whole (Cho, 2015). Altmetrics is an activity that measures the degree to which academic research papers and research data respond to social media on the Web. In general, various types of tools are being developed for analyzing aggregated data by reflecting the various activities of readers such as views, downloads, clicks, memos, saves, tweets, shares, and bookmarks. In the meantime, open access papers in the changed academic communication environment are known to be more likely to be cited and have a higher social impact. In the field of physics, gold OA is receiving more attention (Robinson-García et al., 2018). In the field of informatics, it has been reported that open access articles have a positive impact on the number of mentions in social media (Cintra et al., 2018). In Nature Communications articles, open access papers have been reported to receive more article views and social media mentions (Wang et al., 2015). In addition, various results have been published

confirming the positive effect of open access on the impact of research.

Meanwhile, among the academic disciplines, the social sciences are most often associated with human societal activities and interests. In particular, research outcomes in politics, international relations, and various social issues can be socially sensitive. Therefore, nonacademic readers are more common than in other fields, and they can lead to public discussion. Therefore, this study used an altmetrics measurement tool to identify the social impact of scientific research achievements in the social sciences and the differences in sub-disciplines. In addition, it examined what type of relationship exists between the altmetrics and citations and then the understanding of how the open access status of a paper affects the altmetrics. To accomplish the purpose of this study, the following research questions were developed:

RQ1) What is an altmetric Attention score of highly cited articles in social sciences?

RQ2) Does the altmetrics of highly cited social science articles correlate with the citation number?

RQ3) Does the open access status affect the citation and altmetrics?

RQ4) Are there differences between the 10 sub-disciplines of social sciences in the altmetrics score?

Materials and methods

This study searched social sciences in the subject field without restricting the year in SCOPUS. The author extracted 800 cases by citation rank after searching SUBJAREA (soci) in the advanced search. Articles were excluded that fell outside the social sciences category. The author also extracted 638 bibliographic data from academic journal articles. Although the subject category was limited to social sciences in the searching process, the search results included cases where multiple subjects were assigned. Therefore, the subjects assigned by Scopus for the searched journal titles were checked one by one, and articles in the journals that were far from social science were excluded. Articles in the journals with mathematics, nursing, computer science, neuroscience, medicine, engineering, agricultural and biological sciences assigned as the main subject category were excluded.

The analysis of the articles was divided into the following ten social sciences sub-categories by referring to the SCOPUS sub-categories assigned to the source journal. The ten assigned sub-categories are as follows: administration/management, anthropology/human

science, economy, education, health, information/communication, politics, psychology, sociology, and linguistics. Sub-categories of social sciences also include the health sectors, which include social health, health administration, and more. For example, the following journals, *Journal of Urban Health, Social Science and Medicine, Sociology of Health & Illness*, are also included in the social sciences. The subjects applied to the articles were the ones assigned by SCOPUS for the source journals, but a scan of keywords in the journal titles was also performed. In addition, in cases where multiple topics were assigned to the journals by SCOPUS, the first assigned category was adopted.

Next, altmetrics scores were collected using PlumX, and articles were checked to determine if they were open access (OA) or used Unpaywall. As for OA, in addition to the gold method in which the journal itself is OA, there are methods such as green, hybrid, and bronze. Green refers to the way authors self-archive in OA repositories, and hybrid refers to a way that author processing charges (APCs) are paid for, even if published in a subscription-based journal, so that anyone can read it immediately. In addition, bronze does not have a Creative Commons Attribution (CC BY) license, meaning that even if it is open access, it is not known when it will be changed to closed. In this study, since the OA method was confirmed on an article-by-article basis, an open access article does not necessarily equate to an article from an OA journal. Meanwhile, collected altmetrics information included EBSCO full-text view, Mendeley reader, blog mentions, Wikipedia references, and Tweets. The collected data were analyzed using the following procedure.

First, this study presented the altmetrics and open access statistics of highly cited social science articles. The author also identified the papers with high altmetrics score. Second, in order to examine the relationship among citation numbers, altmetrics scores, and open access status, the author performed a Spearman's rank correlation analysis to see if high citations show a high altmetrics presence. Spearman's rank correlation analysis is a nonparametric measure of the statistical dependence between the ranks of two variables. After this analysis, a Mann-Whitney test was performed to see if open access articles show a high citation rate and altmetrics score. Mann-Whitney is a nonparametric analysis that analyzes the difference between two groups. Nonparametric analysis is a method that makes no assumptions about the shape or parameter values of the population. Decisions about whether to use parametric or nonparametric analysis can be verified with the Shapiro-Wilk test.

Third, the author verified if there are differences in open access and altmetrics in 10 social science sub-disciplines. To complete this task, a correspondence analysis was conducted to visually examine the relationships between social media mentions and the 10 sub-disciplines. To perform the correspondence analysis, the presence of a social media mention was converted into a binary value. For example, if an article had one or more social media mentions, it was set to 1; otherwise, it was set to 0. The analysis results were visually presented on a two-dimensional map. Correspondence analysis, a type of multidimensional scaling method, is a technique for determining the relationship between variables by calculating optimal quantization values for row and column categories and plotting the data on a two-dimensional plane. All the aforementioned statistical analyses, including descriptive statistics, were performed using SPSS 32.

Literature review

Attempts have been made to review and improve a new assessment of research impact. SAGE stated that the evaluation of research impacts based on the number of citations could not explain the impact on the public. Because citations cannot track social impacts, it is necessary to use an alternative impact assessment system in the social sciences field (SAGE Publishing, 2019). Elsevier also launched an international center, “The International Center for the Study of Research” (ICSR) (<https://www.elsevier.com/icsr>), whose mission is to review and improve research evaluation methods across all areas of intellectual production. They are developing qualitative and quantitative metrics for transparent and robust research evaluation in conjunction with a bibliometrics, scientific metrology, and the research evaluation community. The National Information Standards Organization (NISO) also announced the need to utilize academic performance data other than existing academic publications and then reported on the definition and use cases of altmetrics (NISO, 2016). In addition, the *Journal of Altmetrics*, a specialized journal covering altmetrics data analysis and comparison to other metrics, was launched in September 2018 (<https://www.journalofAltmetrics.org/>).

Altmetrics is a measure of the impact of research obtained by measuring the extent to which academic research papers and research data respond to social media on the Web. Web-based applications such as Plum analytics (plumanalytics.com) and Altmetrics.com (<https://www.altmetric.com>) were developed to measure

the social impact of research. Altmetrics visualizes how much attention has been paid to articles and research data in social media and bibliographic management tools. Verification is being conducted by various researchers (Haustein et al. 2015; Zahedi et al. 2014). SCOPUS (www.scopus.com) and citation index databases have already been used as a complementary impact explanatory tool.

Studies on the effect of altmetrics applications in the Humanities and Social Sciences (Hammarfelt, 2014; Mohammadi & Thelwall, 2014) and the relationship between altmetrics and bibliometrics (Li & Thelwall, 2012; Serrano-Lopez et al., 2017; Zahedi et al., 2014) have been conducted. The limitations and advantages of altmetrics have also been actively discussed (Gumpenberger et al., 2016).

In addition, the following research was conducted on altmetrics in the social sciences. Htoo and Na (2015) compared altmetrics in psychology, language, and history. Among the three social sciences, psychology has the highest citation rate and five of ten altmetrics sources have been reported to be correlated with citation rates. However, the language and history fields showed a correlation with the citations only in two altmetrics sources. Therefore, Htoo and Na (2015) concluded that altmetrics could be meaningfully used in the psychology field compared to other fields. Thelwall (2018) reported that in the humanities and social sciences a number of papers exist in which the altmetrics was not registered. He noted that nearly all articles in the humanities and social sciences that are exposed to social network sites (SNS) were for publicity or personal activities rather than public discourse. Thelwall also noted that the humanities and social sciences have potential audiences online, but the altmetrics figures are small. He added that there was no altmetric source with a non-zero value of 12% or more and differences in discipline existed as follows: literature is the least exposed field; archeology is often exposed on Facebook; and social, political, and gender studies are exposed to news sources. De Filippo and Sanz-Casado (2018) compared bibliometrics to altmetrics in the fields of communication, economics, and sociology. As a result of studying Social Sciences Citation Index papers published during the period 2013–2015, economics showed the highest citation rate but social media exposure was high in communications and sociology. The correlation between citations and social media is low, but almost all of the highly cited papers have mentions in social media. In addition, tweets were analyzed to be the most exposed altmetrics sources in social media. These results are

Table 1. OA or closed article.

OA status	Frequency	%
Open	175	27.4
Closed	414	64.9
Missing	49	7.7
Total	638	100.0

the same as those of previous studies in which Mendeley and Twitter are the most common altmetrics sources (Costas et al., 2015; Thelwall et al., 2013). Robinson-García et al. (2014) also stated that altmetric mentions of 65–87% were found on Twitter and Mendeley, and others were found to be less than 20%. Meanwhile, Tint and Na (2017) suggested that altmetrics in psychology, health care, and politics could be a leading indicator of citation. They stated that “therapy” in psychology, “HIV” in health care science are keywords that show the highest tweet presence. Similar to previously mentioned studies, they noted that Mendeley and Twitter are the main sources of altmetrics, and there is a strong correlation between Mendeley and citation rates.

Summarizing the aforementioned precedent research results, the articles in the field of humanities and social sciences mostly show low altmetrics figures. However, they are relatively sensitive to tweets in social media. The correlation between citations and social media is low but clearly a correlation exists between Mendeley and citations. Each study has different results depending on how the academic disciplines are divided, how the data period is used, and how the size of the sample is set. This study explored the relationship between open access, citations, and altmetrics by extracting only papers highly cited in the social sciences as a sample. In addition, this study will differentiate the previous studies in terms of analyzing the differences between the 10 sub-disciplines in social science.

Analysis results

General statistics

This section presents the study’s results of analyzing the open access status, distribution of academic fields, and article altmetrics statistics. This relates to RQ1.

First, 27.4% of the articles analyzed were open and 65% were closed as shown in Table 1. The data on the green, gold, and bronze open access methods are difficult to accurately investigate and are not presented here.

Second, psychology ranked the highest with 25.6% of the 638 analysis data, followed by sociology (11.6%) and administrative/management (11.3%) as shown

Table 2. Distribution of fields.

Fields	Frequency	%
Administration/management	72	11.3
Anthropology/Human science	30	4.7
Economy	54	8.5
Education	66	10.3
Health	55	8.6
Information/communication	41	6.4
Politics	40	6.3
Psychology	165	25.9
Sociology	74	11.6
Linguistics	41	6.4
Total	638	100.0

Table 3. Altmetric presence.

Altmetric source	N	Minimum value	Maximum value	Mean
View	638	0	83,912	2,123.41
Reader	638	0	65,840	1,496.95
Blog	638	0	14	0.60
Wiki	638	0	13	1.52
Tweet	638	0	1,162	6.18
citedby	638	1,077	39,005	2,098.83

Table 2. Those of psychology seems to be the most highly cited social science papers.

Third, as a result of comparing the number of altmetrics presence as shown in Table 3, full-text view (2,123) was the largest followed by the reader count (1,496). The number of citations (2,098) for the articles was less than the full-text view (2,123) and higher than the reader count (1,496). However, the average frequency of social media referrals is in the order of tweets (6), wiki references (1), and blog mentions (0.6). As shown in previous studies, tweets have the highest mean. However, the difference found in this study was that the altmetrics score is relatively high. The reason for this is that the analysis was limited to papers that are highly cited.

Fourth, this study summarized the result of frequency analysis once again by converting the altmetrics presence to a binary code. The author set the value to 1 when the altmetrics presence is greater than one and set the value to 0 otherwise. As a result, the view and reader counts were found to have more than one presence in more than one-half of the papers as shown in Table 4. Particularly in Mendeley readers, greater than 90% of the papers were registered and wiki shows a non-zero at 56.1%. More than one-half of the papers to be analyzed are registered as references in wiki, which means that many of the papers have been used for academic purposes on wiki. As discussed in detail later, many psychological papers are registered as a wiki reference. In previous studies, Thelwall (2018) found that few articles have at least one altmetrics mention. However, in this study, which analyzed highly cited articles in the social sciences, it

Table 4. Altmetrics presence by source.

Division	Frequency	%
View		
Y	362	56.7
N	276	43.3
Sum	638	100.0
Reader		
Y	600	94.0
N	38	6.0
Sum	638	100.0
Blog		
Y	216	33.9
N	422	66.1
Sum	638	100.0
Wiki		
Y	358	56.1
N	280	43.9
Sum	638	100.0
Tweet		
Y	248	38.9
N	390	61.1
Total	638	100.0

was found that greater than 30% of articles had one or more altmetrics presence in all sources.

Fifth, this study reviewed the papers that have a noticeably higher presence in each of the altmetrics sources. The highest score (83,912) in the full-text view was found for “Learning styles and learning spaces: Enhancing experiential learning in higher education” (Kolb and Kolb 2005), an article on higher education in the *Academy of Management Learning and Education*. The most popular paper (65,840) with the most readers was “The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations” (Baron and Kenny, 1986) in the *Journal of Personality and Social Psychology*. This is the most cited article in the field of social psychology, and it has been cited 39,005 times. However, in social media, the most mentioned paper (14) in blogs was “E pluribus unum: Diversity and community in the twenty-first century 2006 Johan Skytte prize lecture appearance” (Putnam, 2007), which was published in *Scandinavian Political Studies*. This paper is the most mentioned in blogs related to immigration and racial diversity in developed countries on politics. It is also the most widely tweeted paper (1,162) leading to discussions on social solidarity and diversity. Finally, the most widely referred article (13) in wiki is “Unskilled and unaware of it: How difficulties in recognizing one’s own incompetence lead to inflated self-assessments,” (Kruger and Dunning, 1999), which was published in the *Journal of Personality and Social Psychology*. This paper has been cited as a reference to wiki such as psychological and cognitive science related to cognitive dissonance and self-hypothesis. In addition, “Revolution that was not: A New Interpretation of the

Table 5. Relationship between citation, view, and reader.

	citedby	View	Reader
Spearman’s rho			
citedby			
Correlation coefficient	1.000	0.123	0.410
Probability of significance		0.002	0.000
N	638	638	638
View			
Correlation coefficient	0.123	1.000	0.348
Probability of significance	0.002	.	0.000
N	638	638	638
Reader			
Correlation coefficient	0.410	0.348	1.000
Probability of significance	0.000	0.000	
N	638	638	638

Origin of Modern Human Behavior” (McBrearty and Brooks, 2000), published in the *Journal of Human Evolution*, was cited many times from anthropology-related Wikipedia including anthropological issues such as human development and homo sapiens.

Analysis of the relationship between citations, altmetrics, and open access

This study assessed whether highly cited articles show high altmetrics and whether the open access papers show high altmetrics. This relates to RQ2–3.

Relationship between altmetrics and citation number

In order to solve RQ2, let’s look at the relationship between citation number and altmetrics. For this purpose, this study performed analysis of Spearman’s rank correlation between the number of citations, views, and readers at first as shown in Table 5. As a result, there was no correlation between the number of citations and the full-text view, but it was found that there was a relationship between the number of citations and the readers. The number of Mendeley readers most frequently used in the altmetrics is strongly correlated with citations ($r=0.410$). Correlation analysis is a technique used to grasp the relationship between two variables. It has a correlation coefficient indicating the direction and intensity of the relationship between the two variables. Usually, 0.0–0.1 is almost irrelevant 0.1–0.2 means weak positive correlation, 0.2–0.4 means normal positive correlation, and from 0.4, it means relatively strong positive correlation. This is because researchers of future articles are likely to bookmark academic papers closely related to their current research topic. Therefore, articles that are bookmarked by a researcher are likely to be cited in a future researcher’s papers. However, full-text views are likely to have been approached by someone who is not to be an author of future

Table 6. Relationship between citedby, blog, Wiki, and Tweet.

	citedby	Blog	Wiki	Tweet
Spearman' rho				
citedby				
Correlation coefficient	1.000	0.227	0.264	0.066
Probability of significance	.	0.000	0.000	0.094
N	638	638	638	638
Blog				
Correlation coefficient	0.227	1.000	0.201	0.276
Probability of significance	0.000	.	0.000	0.000
N	638	638	638	638
Wiki				
Correlation coefficient	0.264	0.201	1.000	0.274
Probability of significance	0.000	0.000	.	0.000
N	638	638	638	638
Tweet				
Correlation coefficient	0.066	0.276	0.274	1.000
Probability of significance	0.094	0.000	0.000	.
N	638	638	638	638

Table 7. Relation between open access and citation.

Open	N	Mean	Rank sum
citedby			
Open	175	308.03	53,906.00
Closed	414	289.49	119,849.00
Sum	589		

published articles, such as practitioners, clinicians, and students. They are just browsing and collecting basic papers for learning or practical tasks. Therefore, the probability that the article is cited in future articles will be lower than the Mendeley bookmarked articles. However, there was a weak correlation ($r=0.261$, $r=0.232$) with wiki and blogs in the relationship between citations, and it did not appear to be correlated with tweets and citations as shown in Table 6. However, there is a weak correlation among social media, such that a paper that has been noticed through a particular SNS can be interpreted as having a weak correlation to be mentioned through another SNS.

The effect of open access on citation and altmetrics

Let's take a look at how open access affects citation and altmetrics. This relates to RQ3. At first, to investigate whether open access affects citations, the author examined the normality of each group using the Shapiro–Wilk test. Shapiro–Wilk is a method of testing whether the data to be analyzed is normally distributed. Through this method, it is possible to determine whether parametric analysis is possible or whether nonparametric analysis should be performed. Because all articles could not be normally distributed with a $p=0.00$, a nonparametric test, the Mann–Whitney test, was performed. The results of the Mann–Whitney test (see Tables 7 and 8) showed that the average ranking was higher for open access articles. However, the probability of significance is $p=0.227$, which is statistically significant only at 77%,

Table 8. Mann–Whitney test results.

	citedby
Mann–Whitney <i>U</i>	33,944.000
<i>Z</i>	−1.209
Probability of approximate significance	0.227

Table 9. Open access difference in Altmetrics.

Open	N	Mean rank	Rank sum
View			
Open	175	298.73	52,277.50
Closed	414	293.42	121,477.50
Sum	589		
Reader			
Open	175	321.85	56,324.50
Closed	414	283.65	117,430.50
Sum	589		
Blog			
Open	175	303.88	53,178.50
Closed	414	291.25	120,576.50
Sum	589		
Wiki			
Open	175	303.22	53,063.50
Closed	414	291.53	120,691.50
Sum	589		
Tweet			
Open	175	318.64	55,762.50
Closed	414	285.01	117,992.50
Sum	589		

in other words, whether or not open access has a significant effect on the number of citations.

Second, to determine how open access affects the altmetrics presence, author first checked the normality of each group using the Shapiro–Wilk test, which did not form a normal distribution ($p=0.00$). As a result of the nonparametric tests, the average rankings of all the open papers were higher in all the altmetrics sources as shown in Table 9. However, statistically, it was significant only in reader counts ($p=0.013$) and tweet ($p=0.014$) as shown in Table 10. Thus, while open access papers tend to receive higher mentions in all social media, readers and tweets have statistical significance.

Table 10. Mann-Whitney test results.

	View	Reader	Blog	Wiki	Tweet
Mann-Whitney <i>U</i>	35,572.500	31,525.500	34,671.500	34,786.500	32,087.500
<i>Z</i>	-0.356	-2.490	-0.968	-0.798	-2.460
Probability of approximate significance	0.722	0.013	0.333	0.425	0.014

Table 11. Open access difference in 10 social science sub-disciplines.

Sub disciplines	Open access status		
	Open	Closed	Total
Administration/management	20 29.9%	47 70.1%	67 100.0%
Anthropology/Human Science	10 38.5%	16 61.5%	26 100.0%
Economy	21 43.8%	27 56.3%	48 100.0%
Education	15 25.4%	44 74.6%	59 100.0%
Health	11 25.6%	32 74.4%	43 100.0%
Information/communication	12 32.4%	25 67.6%	37 100.0%
Politics	9 23.7%	29 76.3%	38 100.0%
Psychology	48 29.3%	116 70.7%	164 100.0%
Sociology	58 19.4%	72 80.6%	130 100.0%
Linguistics	15 42.9%	20 57.1%	35 100.0%
	175 29.7%	414 70.3%	589 100.0%

Table 12. Chi square test results.

	Value	Degree of freedom	Probability of significance
Pearson Chi squared	13.692	9	0.134
Effective cases	589		

Open access and altmetrics differences among the 10 Sub-disciplines

Differences in open access and altmetrics among the 10 social science sub-disciplines were assessed. This relates to RQ4.

First, when reviewing the proportion of open access status in the 10 sub-disciplines of social science, economics and linguistics are relatively high as shown in Table 11. However, the chi-square result as shown in Table 12, $p = 0.134$, is not statistically significant. It is interpreted that the difference between disciplines in terms of open access does not mean much.

Meanwhile the results of the Kruskal–Wallis test to assess if there is a difference in the altmetrics show the academic disciplines have a clear difference as shown Tables 13 and 14. The Kruskal–Wallis test is a

Table 13. Altmetrics difference in social science sub-disciplines.

Sub-disciplines	<i>N</i>	Rank mean
View		
Administration/management	72	457.37
Anthropology/Human Science	30	279.17
Economy	54	308.31
Education	66	275.09
Health	55	231.99
Information/communication	41	330.82
Politics	40	297.03
Psychology	165	334.87
Sociology	74	366.61
Linguistics	41	174.26
Sum	638	
Reader		
Administration/management	72	351.10
Anthropology/Human Science	30	365.53
Economy	54	269.91
Education	66	374.70
Health	55	226.95
Information/communication	41	316.48
Politics	40	312.23
Psychology	165	333.50
Sociology	74	337.34
Linguistics	41	252.51
Sum	638	
Blog		
Administration/management	72	270.10
Anthropology/Human science	30	322.13
Economy	54	296.06
Education	66	332.96
Health	55	309.08
Information/communication	41	338.89
Politics	40	310.80
Psychology	165	327.39
Sociology	74	338.15
Linguistics	41	351.18
Sum	638	
Wiki		
Administration/management	72	300.20
Anthropology/Human science	30	266.93
Economy	54	225.10
Education	66	278.85
Health	55	304.39
Information/communication	41	304.24
Politics	40	294.04
Psychology	165	393.61
Sociology	74	322.51
Linguistics	41	338.29
Sum	638	
Tweet		
Administration/management	72	342.40
Anthropology/Human science	30	366.33
Economy	54	303.41
Education	66	353.98
Health	55	325.59
Information/communication	41	284.35
Politics	40	360.24
Psychology	165	277.68
Sociology	74	362.90
Linguistics	41	287.94
Sum	638	

one of nonparametric analysis that is a commonly used method for testing the average of three or more groups. Disciplines of a high average ranking of each source were as follows: view – admin/management, reader – education, blog – information and communication, wiki – psychology, and tweet – humanity and sociology. All sources except blogs showed statistically significant values. Administrative/business papers with extensive readership were the most widely read. Articles that were bookmarked the most in Mendeley were education. Registered references in Wikipedia were the highest for psychology, and the disciplines that led to the public debate through tweets were highly represented by anthropology, sociology, and politics.

To better understand the relationship between social media and social science sub-disciplines, a correspondence analysis to help visualize the results was conducted. As a result of analyzing the presence or absence of altmetrics and converting them into binary values, the results were slightly different from the average ranking scores of the ranking tests; however, nearly similar results were obtained as follows. The explanatory power was 76.5% in one dimension and 100% in two dimensions, and the probability of significance was $p=0.02$. As a result of plotting on a

two-dimensional map, a triangle was formed by wiki on the right side of the map, tweet on the left side, and blog on the lower side. The management/administration field was pushed out of the SNS triangle on the map and most other fields were in the vicinity of the triangle. This can be interpreted that the management/administration field is weaker than the social media exposure. However, the area nearest wiki was psychology, the fields that are nearest tweets are politics and sociology, and finally blogs are interpreted as nearest to information science and linguistics. In wiki, psychology articles are referenced in Wikipedia information on cognitive dissonance, illusory superiority, availability heuristic, self-hypothesis, and so on. Meanwhile, it has been confirmed that there are a number of papers mentioned in tweets that lead to social debates such as those regarding immigration, multiculturalism, politics, and social issues (Figure 1).

Discussion

First, the results of the research questions regarding the OA status and altmetrics attention in highly cited social science articles are summarized as follows. Less than 30% of the cited articles are open access and the remainder are mostly closed. In addition, in an

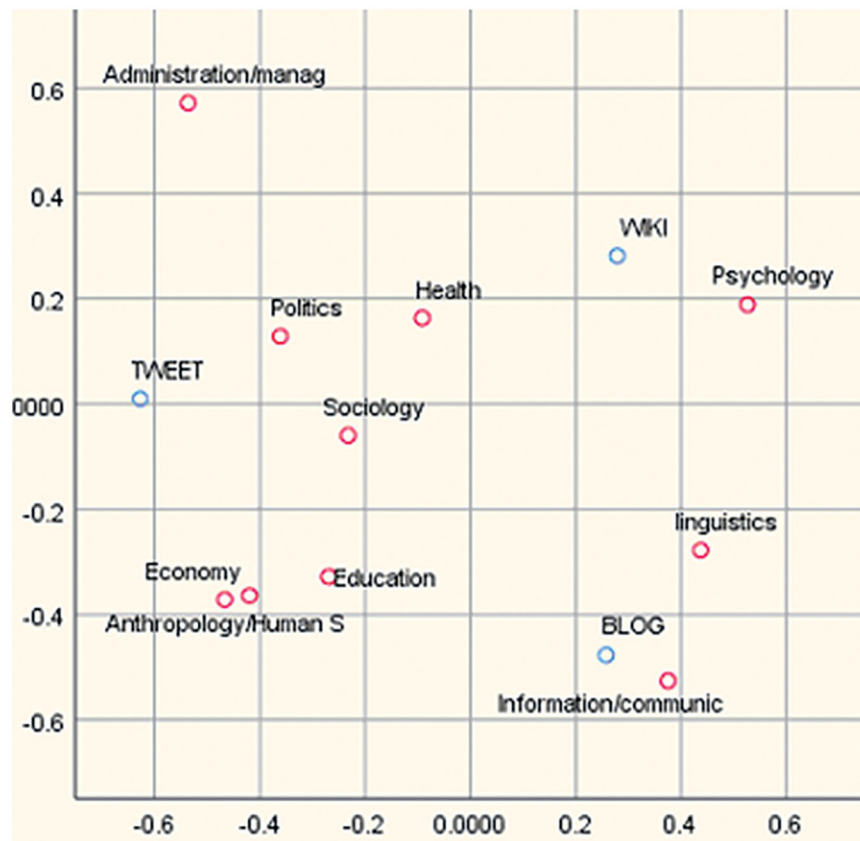


Figure 1. Two-dimensional plotting results of the relationship between SNS mentions and social science sub-fields.

altmetrics source, view and reader have high scores but the social media exposure is not relatively high. However, because this study analyzed highly cited papers, greater than 30% of all altmetrics sources were non-zero. Among them, 90% of the articles have one or more reader in Mendeley, and 50% of articles have one or more mentions in wiki references; therefore, Mendeley reader and wiki reference in altmetrics presence show a relatively sensitive response in highly cited papers.

Second, the answers to the questions of whether the altmetrics of the highly cited articles of the social sciences has a correlation with citations, and whether open access affects the citation rate and altmetrics scores are presented as follows. There is a strong correlation between the number of citations and the number of readers, $r=0.4$, indicating that the number of Mendeley readers increases as the number of citations increases. In social media, only wikis and blogs showed a weak correlation.

Third, the answer to the question of whether open access affects the citation number and the altmetrics can be presented as follows. As a result of the correlation analysis between open access papers and citation number, open access papers were cited more but no differences were statistically significant. In altmetrics, open access papers showed more presence in all sources but the only statistically significant differences were found in reader and tweets.

Fourth, whether there are differences among the 10 sub-disciplines of social sciences in terms of open access and altmetrics are discussed as follows. The field with many open access papers was economics, but it was not statistically significant. A difference was found between the altmetrics scores according to the source. The disciplines of high average ranking of each source were as follows: view – administrative/management, reader – education, wiki – psychology, and tweets – humanity, society, and politics.

The findings that the open access papers have a greater influence, the Mendeley reader has a strong correlation with citations, and the altmetrics are different according to the academic disciplines are in common with several previous studies. However, this study was focused on highly cited papers, thus the author found new research results that were not found in previous studies. The point is that in the case of highly cited papers, greater than 30% have more than one altmetrics presence and there were many papers that were used as references in wiki. This is also a notable discovery not found in other studies that were not limited to highly cited papers.

However, the study has research limitations; the source of the altmetrics tool used in this study is limited. The view provided by Plum Analytics is limited to the EBSCO View, and the reader is limited to Mendeley Reader. Facebook and news sources were also excluded. Therefore, different results may be obtained when using other altmetrics tools. In addition, if the range of the papers is different, different results may be obtained.

Conclusions

The evaluation of the research impact on the number of citations could not identify the actual impact on policy or the public. In the field of social sciences, it is necessary to discuss an alternative impact evaluation system that can include the actual effects on society. Though citations can describe only the impact on author of other papers, that is, the influence of academics, altmetrics can capture influences outside the academic world from various perspectives.

In particular, Mendeley readers have a strong correlation with citations and can track the impact of research results read and bookmarked by various audiences, although not author in academia. Social media, however, has a weak correlation with citations, but it can identify the impact of academic achievements that lead to public discussion and interest. However, notably, the sensitive disciplines vary depending on the altmetrics source. Psychology in wiki and sociology, politics, and anthropology in Twitter were highly exposed but other disciplines were not. Thus, there were obvious characteristics depending on the disciplines.

In addition, although the author did not investigate this in this study, SNS sensitivities may vary depending on the research subjects, even in the same research field. As shown by Tint and Na (2017), “therapy” in the field of psychology and “innovation” in management were highly sensitive for altmetrics. As social influences show different aspects according to the subject of the research field of study, it is necessary to search for appropriate application direction as an influential evaluation tool of alternative research considering this point.

However, it is meaningful to analyze the detailed topics in which research shows a high altmetrics presence in a subsequent study. It is also meaningful to identify detailed research topics that lead to a public discussion by extracting keywords and performing keyword-based network analysis and to compare these to the intellectual structure based on research

Table 14. Kruskal-Wallis test results.

	View	Reader	Blog	Wiki	Tweet
Kruskal-Wallis's H	98.354	34.826	13.384	54.571	30.003
Degree of freedom	9	9	9	9	9
Asymp. Sig.	0.000	0.000	0.146	0.000	0.000

publications, which is a traditional method. Additionally, in future study, analysis of science disciplines other than the social science field would be useful. Choi (2019) reported that as a result of analyzing the altmetrics of Korean government-sponsored projects in the field of basic science, the fields of physics and life science showed high sensitivity but were low in mathematics. However, it will be necessary to try to analyze the social influence of the scientific field using a wider range of publications. And it will be necessary to explore how the degree of and exposure to social media and usage amount appear different from the social science field.

It has been argued that OA papers, which are rapidly increasing in the open science environment, can have more readers and higher influence. Many researchers have analyzed the positive or negative effects of OA papers on citation and altmetrics, but research results showing differences depending on the academic fields or country have been presented. In order to prove the causal relationship between OA and citation, additional analysis is required, and additional verification is also required concerning whether OA reacts more sensitively to altmetrics. The PlanS Principle has been established for realizing full and immediate open access to publicly funded research outcomes. Publicly funded research outcomes published after January 2021 in the European Union must be published in the open access journal or deposited on the immediately available open access platform. Many journals are at a crossroads for the OA transition. Since there will be more OA papers in the future, more research in this field will be needed.

Table 14 Kruskal-Wallis test results.

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