The $h^{(3)}$ – index of academic journals

Yves Fassin[1] and Ronald Rousseau[2,3*]
[1]Department of Marketing, Innovation and Organisation
Faculty of Economics and Business Administration
Ghent University, Belgium
Tweekerkenstraat, 2, 9000 Gent, BELGIUM
[2]University of Antwerp, Faculty of Social Sciences,
Middelheimlaan 1, 2020 Antwerpen, BELGIUM
[3]KU Leuven, MSI, Facultair Onderzoekscentrum ECOOM,
Naamsestraat 61, 3000 Leuven, BELGIUM
E-mail: fassin@skynet.be; Yves.Fassin@Ugent.be
*ronald.rousseau@uantwerpen.be; ronald.rousseau@kuleuven.be (corrresponding author)

ABSTRACT
The objective of this paper is to show that the already existing $h^{(3)}$ indicator, designed after the h-index and Kosmulski's $h^{(2)}$-index, has some advantages with respect to the classical h- or $h(^2)$-indices, when it comes to academic journal evaluation. The $h^{(3)}$-index for journals is defined as the largest natural number h_3 such that the first h_3 publications each received at least $(h_3)^3$ citations. Because of its tough requirement it is difficult to have a high $h^{(3)}$-index. Consequently, this index is more selective than the classic h and $h^{(2)}$-indexes. It enjoys a greater stability and is simple to determine as it necessitates only a small number of most-cited articles of a journal and varies only every 2 to 5 years. We admit though that like many other indicators the $h^{(3)}$ indicator is only PAC (Probably Approximately Correct). Yet, it is proposed as a simple and valuable alternative to the more complex and contested Journal Impact Factor.

Keywords: h-index; h-type indices; Journal studies; Pearson correlations; Journal Impact Factor

INTRODUCTION

Different metrics have been developed to evaluate journal impact, journal influence, and indirectly (aspects of) journal quality (Rousseau et al. 2018). Among these we mention the Journal Impact Factor (JIF), based on Clarivate's Web of Science (WoS) and the SCImago Journal Rank (SJR)-index based on Scopus. Recently, the JIF and other journals indexes have been criticized on several aspects, including the lack of transparency (da Silva and Memon 2017; Bohannon 2016). JIF-based rankings as shown in the Journal Citation Reports give the false impression of being very precise (as results are shown with three decimals). Moreover, they depend on data only known to the database owner (Vanclay 2012; Kiermer et al. 2016).

This contribution is based on a presentation by the first author in Fassin (2018). We introduce now the topics covered in the following sections and their relations. In the next section we recall the definitions of the h-index and other h-type indices such as the g-index, the $h^{(2)}$- index and the $h^{(3)}$-index. This is followed by a discussion about the growth of these indices over time, illustrated by citation data of three scholarly journals with different properties:

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Scientometrics, *Strategic Management Journal* and *Nature*. Next, we expand the journal set of examples for which we calculate h-type indices. Pearson correlations are calculated for a set of management journals showing a high correlation between the h-, $h^{(2)}$ and $h^{(3)}$ values. This is followed by a discussion of our observations, leading to the conclusion that, because the $h^{(3)}$-index for journals is highly correlated to the h-index, and because it is much easier to determine, it should be the preferred method to find a h-type index for a journal. This indicator is, moreover, more stable than the classical h-index. It is proposed as a simple but valuable alternative to the JIF and other indexes for journals that have been subject of criticism in recent years (Vanclay 2012; Wouters et al. 2019).

h-TYPE INDICES

The h-Index

We recall that the h-index of scientist S is defined as follows (Hirsch 2005). Consider the list of publications (co)-authored by scientist S, ranked according to the number of citations each of these publications has received. Publications with the same number of citations are given different rankings. Then the h-index of scientist S is h if the first h publications received each at least h citations, while the publication ranked h+1 received strictly less than h+1 citations. Stated otherwise: the h-index of scientist S is the largest natural number h such that the first h publications received each at least h citations. The h-index, although originally defined for single authors, can be defined for journals (Braun et al. 2005). Applying this definition to the set of all articles published in journal J leads to the definition of this journal's h-index. We note that indicators based on publications and citations can be defined for different publication and citation windows, not necessarily of the same length. The above definitions of the h-index are 'total career' or 'total existence' h-indices, but it often makes more sense to restrict to given publication and citation windows. Of course, citations are retrieved from a database and results differ depending on the used database (Bar-Ilan 2008; Harzing and van der Wal 2009). Data used in this investigation are retrieved from a version of the WoS which goes back to 1955. Moreover, as we focus on journals we will discuss results in terms of academic articles (not publications, a term that includes monographs, textbooks, unpublished papers and possible other forms of scholarly or even enlightenment literature).

The g-Index and Other h-Type Indices

As an increase in the number of citations received by articles in the h-core (defined here as the set of all articles with at least h citations) does not influence the value of the h-index, another index has been invented which does. This is the g-index, proposed by Egghe (2006). It is determined as follows: articles are ranked in decreasing order of received citations (as for the h-index). Then the g-index of this set of articles is defined as the highest rank g such that these g articles together received at least g^2 citations.

Another variation was introduced by Kosmulski (2006). He proposed the $h^{(2)}$-index, defined as follows: again one ranks the set of articles for which one wants to determine the $h^{(2)}$-index in decreasing order of received citations. Now this set (author, journal, etc.) has an $h^{(2)}$-index equal to h_2 if $r = h_2$ is the highest rank such that the first h_2 articles each received at least $(h_2)^2$ citations. Kosmulski observed that this definition makes it easier (than for the h-index) to handle long lists. As an example we mention Hua et al. (2009) who applied Kosmulski's index to download data.

As a next step, colleagues observed that one may define in a similar manner an $h^{(k)}$ -index (k=1,2,3,….). This has been done e.g. in Deineko and Woeginger (2009), who proposed an axiomatic characterization of an even more general family of indices and in Egghe (2011), who studied this index in a Lotkaian framework. However, to the best of our knowledge, those theoretical principles have never been applied to individual datasets of researchers or journals. We note that the h, $h^{(2)}$ and $h^{(3)}$ -indices of the whole WoS (data from 1955 till August 2018) are respectively: 2912, 123 and 31.

Definition of the $h^{(3)}$-Index of Journals

For clarity's sake we now recall the definition of the $h^{(3)}$ index for journals in detail. Consider the list of articles published in journal J, ranked according to the number of citations each of these articles has received. Articles with the same number of citations are given different rankings. Then the $h^{(3)}$-index of journal J is h_3 if the first h_3 articles received each at least $(h_3)^3$ citations, while the article ranked h_3+1 received strictly less than $(h_3+1)^3$ citations. Stated otherwise: the $h^{(3)}$-index of journal J is the largest natural number h_3 such that the first h_3 publications each received at least $(h_3)^3$ citations. Table 1 provides data of a fictitious journal J to illustrate the definitions. Journal J's values of its h, $h^{(2)}$ and $h^{(3)}$ indices are resp. 8, 5 and 3.

We note that by their very definition, and for any dataset: $g \geq h \geq h^{(2)} \geq h^{(3)}$ (illustrated in Tables 2,4,6), where the equalities between g, h, $h^{(2)}$ and $h^{(3)}$ occur only very rarely. Such cases are studied in Egghe et al. (2018), but will play no role further on.

Table 1: Data for the Calculation of the h, $h^{(2)}$ and $h^{(3)}$ -Index of a Fictitious Journal J

Ranked articles	Squared rank	Cubed rank	Number of received citations
A1	1	1	100
A2	4	8	70
A3	9	27	40
A4	16	64	30
A5	25	125	30
A6	36	216	25
A7	49	343	12
A8	64	512	10
A9	81	729	8
A10	100	1000	8
…	…	…	…

When describing applications to real journals, we consider all publications in journal J, to which we refer as articles, including 'normal' articles, reviews, editorials, notes, meeting abstracts etc.

GROWTH OF H-TYPE INDICES

Since the introduction of the h-index by Hirsch (2005) the number of academic journals has substantially increased, and so has the number of published articles, the average length of reference lists and the number of journals selected by the main databases (Althouse et al. 2009; Bornmann and Mutz 2015; Larsen and von Ins 2010; Persson et al. 2004; Sánchez-Gil et al. 2018). Consequently, the number of citations registered in the main databases has increased exponentially. This has in turn led to a rapid increase of journals' h-index and other h-type indexes. Today, (in the year 2019) the h-index of top journals fluctuates, depending on the field: from over 100 to 300 in the management field and up to 1000 in medicine; it reaches values higher than 1,000 for *Science* (h-index = 1,221) and *Nature* (h-index = 1,236) based on data from the WoS, with comparable values in Scopus, but with values up to the double when based on Google Scholar.

As an illustration of the differences in publications and received citations of different scientific outlets, Tables 2 to 7 present data extracted from the WoS related to three academic journals with a totally different profile. First, *Scientometrics*, a leading journal in bibliometrics with a few hundred articles per year; then a very selective general management journal, the *Strategic Management Journal* (*SMJ*), with approximately hundred articles per year, but with quite a few highly cited articles (in the field of management) and as the third one we take *Nature*, one of the leading scientific journals covering all major disciplines with a high publication frequency. Since its establishment *Scientometrics* has published about 5,300 articles, *SMJ* only 2,700 and *Nature*, the eldest journal among these three (established in 1869) nearly 200.000 articles since 1955.

Table 2 presents publication and citation data and h-type index values for the journal *Scientometrics*. The symbol N stands for the total number of publications and CIT for the total number of received citations. Data and index values are those at the end of the period shown in the first column.

Table 2: Publication and Citation Data, and h-Type Index Values of the Journal *Scientometrics* (retrieved on September 16, 2018)

Period	N	CIT	g	h	$h^{(2)}$	$h^{(3)}$
Until 1990	626	1,992	23	17	5	3
Until 1995	1,032	3,750	31	23	6	3
Until 2000	1,530	6,668	39	29	7	3
Until 2005	2,041	11,818	49	36	7	4
Until 2010	2,886	25,695	80	59	10	5
Until 2015	4,369	56,503	126	85	14	6
Until date of retrieval	5,465	81,927	153	98	16	6

Table 3 shows, again for the journal *Scientometrics*, the number of citations of respectively, the most-cited, the 10^{th} most-cited and the 100^{th} most cited articles. We further show the number of citations received by the article ranked at the g^{th}, h^{th}, $h^{(2)th}$ and $h^{(3)th}$ place (denoted as cg, ch, $ch^{(2)}$ and $ch^{(3)}$). Finally, we show the number of citations needed to belong to the top 1% and 0.1% articles in the citation distribution. These values are calculated as the floor functions of N/100 and N/1000, respectively.

Tables 2 and 3 illustrate the increase of the total number of received citations from about 2,000 in 1990 to more than 80,000 by 2018. In that same time period, the number of citations of the most cited article rose from 41 to 762, while for the 10^{th} and 100^{th} most cited article this number increased, respectively, from 24 to 292 and from 7 to 97. The h-index rose from 17 in 1990 to 59 in 2010 and to 97 in 2018. The same indicators calculated for *SMJ*, are presented in Tables 4 and 5.

Table 3: Further Data Related to the Journal *Scientometrics*

Period	Most-cited	10th	100th	cg	ch	$ch^{(2)}$	$ch^{(3)}$	1%	0.1%
Until 1990	41	24	7	15	17	35	35	33	41
Until 1995	63	33	11	21	23	44	49	33	63
Until 2000	113	47	15	25	29	51	62	40	73
Until 2005	134	60	22	32	36	68	83	49	88
Until 2010	184	117	40	48	59	117	139	84	159
Until 2015	562	233	75	65	85	211	260	128	274
Until date of retrieval	762	292	97	77	99	274	341	148	348

Tables 4 and 5 for *SMJ* show an even higher increase than for *Scientometrics*: from 75 to 8,167 citations for the most cited article of that journal, and an h-index that rose from 24 to 271.

Table 4: Publication and Citation Data, and Values of h-Type Indices of *Strategic Management Journal* (SMJ) (retrieved on August 30, 2018)

Period	N	CIT	g	h	$h^{(2)}$	$h^{(3)}$
Until 1990	458	2,505	31	24	6	3
Until 2000	1,115	17,920	102	69	12	5
Until 2010	1,828	99,434	291	173	23	10
Until date of retrieval	2,701	337,594	489	271	33	12

Table 5: Further Data Related to the Journal *SMJ*

Period	Most-cited	10th	100th	cg	ch	$ch^{(2)}$	$ch^{(3)}$	1%	0.1%
Until 1990	75	31	8	20	24	38	53	46	75
Until 2000	449	166	54	53	69	159	213	165	449
Until 2010	3,292	1,035	239	115	173	575	1,035	623	3,114
Until date of retrieval	8,305	2,211	602	169	271	1,121	1,768	1,244	5,009

Tables 6 and 7 present the data for *Nature*, the eldest and most productive journal among these three. Table 6 shows an exponential increase in the number of publications (R^2 = 0.86) and in the number of citations. The h-index of *Nature* increased from 41 in 1960 to 644 in 2000 and reached 1,236 by mid-2018.

Table 6: Publication and Citation Data, and Values of h-Type Indices of the Journal *Nature* (retrieved on August 30, 2018).

Period	N	g	h	$h^{(2)}$	$h^{(3)}$
Until 1960	16,090	58	41	8	4
Until 1970	54,968	178	125	16	7
Until 1980	83,055	353	226	25	9
Until 1990	117,442	676	396	34	12
Until 2000	149,756	1,075	644	46	15
Until 2010	176,384	1,490	925	55	18
Until date of retrieval	196,925	1,971	1,236	69	20

Table 7: Further Data Related to the Journal *Nature*

Period	Most-cited	10th	100th	cg	ch	$ch^{(2)}$	$ch^{(3)}$	1%	0.1%
Until 1960	199	78	27	36	42	82	103	22	61
Until 1970	1,028	405	134	107	125	290	452	61	175
Until 1980	9,486	941	325	184	226	668	976	115	358
Until 1990	80,148	2,057	749	304	396	1,228	1,977	223	693
Until 2000	171,350	3,980	1,550	505	644	2,126	3,601	408	1,323
Until 2010	219,249	7,830	2,496	730	925	3,040	5,938	664	2,091
Until date of retrieval	243,764	11,099	4,000	956	1,236	4,793	8,842	957	2,976

We note that it was easy to find an h-index for the two preceding cases as the number of publications was always smaller than 10,000 and a Citation Report could be retrieved from the WoS. For *Nature* a more refined method, explained in (Rousseau and Zhang 2014) was necessary but, because of improvements in the way WoS functions nowadays, data collection went more smoothly now than in 2014. For the $h^{(2)}$ and $h^{(3)}$ index the same method as described in (Rousseau and Zhang 2014) can be used, but adding columns with squares and cubes (as in Table 1), next to the column with natural numbers.

For the journal *Scientometrics*, the $h^{(2)}$-index increased from 5 in 1990 to 16 in 2018; from 6 to 33 for *SMJ* and from 34 to 69 for *Nature*. While the $h^{(3)}$-index for journals rapidly increases to 4 or 5, the next higher threshold values take longer to surpass. *Scientometrics* rose from an $h^{(3)}$ – value of 3 in 2000 to 4 around 2005, to 5 around 2010, and to 6 around 2015. *SMJ* moved from 5 in 2000 to 10 in 2010 and to 12 by 2018. *Nature* increased from 4 to 12 between 1960 and 1990, and moved up to 20 in 2018. Selectivity (in the sense of becoming more difficult to achieve) of the $h^{(3)}$-core rapidly increased with an increasing $h^{(3)}$-index. *Scientometrics*' $h^{(3)}$-core decreased from 0.48 to 0.11% from 1990 till 2018; *SMJ*'s $h^{(3)}$-core from 0.66 to 0.49%, while *Nature* stabilized around 0.010%.

THE $H^{(2)}$-INDEX AND THE $H^{(3)}$-INDEX FOR JOURNALS

More Illustrations for Different Types of Journals

The $h^{(2)}$-index has been applied to authors (Kosmulski 2006), but not frequently for journals. Just as the h-index, the $h^{(2)}$-index increases, by definition, over the years, but to a lower extent than the h-index. In order to reduce the number of thresholds for attaining the next higher value, and to increase differentiation between successive thresholds, we now consider the $h^{(3)}$-index. By the end of August 2018, only a few journals achieved scores over 15 such as *Nature* with 20 and *Science* with 19.

Table 8 shows the number of articles, the h, $h^{(2)}$ and $h^{(3)}$ indices of well-known journals such as *Science*, *Nature* and *PLOS One* with a very high number of articles and citations. Besides these journals, as an illustration, the same indexes are presented for a number of more specialized publications in different areas of medicine (the *Lancet* and the *New England Journal of Medicine* - NEJ Medicine), bibliometrics (the *Journal of the American Society for Information Science and Technology* - JASIST and *Scientometrics*), physics (*Physics A*), plant sciences (*Cell* and the *European Molecular Biology Organization Journal* EMBO) and management (the *Academy of Management Review* (AMR), the *Harvard Business Review* (HBR), the *Journal of Business Venturing* (JBV), the *Journal of Business Ethics* (JBE) and *Business Ethics A European Review (BEER)*). Table 8 illustrates different citation patterns in a variety of fields. While AMR and HBR are general management journals, JBV and JBE and BEER are specialized journals in subfields in management, entrepreneurship and business ethics.

The list of selected journals in Table 8 shows that most journals have an $h^{(3)}$-index between 6 and 15, with a limited number of journals that surpass the value 15, especially in highly cited domains such as medicine and plant science, and the multidisciplinary top journals *Nature* and *Science*, that reach an $h^{(3)}$-index value of 20 and 19. More recent journals and less reputed specialized journals have an $h^{(3)}$-index value lower than 6. Obviously, there are large differences between journals, depending on the field, the publication frequency of journals and citation patterns in the field.

Table 8: h-Type Indexes for Selected Publications (data collected on August 30, 2018)

Journal title	**N**	**h**	**$h^{(2)}$**	**$h^{(3)}$**
Science	133,507	1221	69	**19**
Nature	196,925	1236	69	**20**
PLoS One	197,901	238	23	**9**
Lancet	175,717	713	48	**15**
NEJ Medicine	96,480	972	60	**17**
Physics Letters A	46,422	201	17	**9**
Cell	20,228	871	56	**17**
EMBO	18,129	439	33	**12**
AMR	2,304	284	34	**13**
HBR	14,419	126	26	**10**
JBV	1,090	144	20	**8**
JBE	7,155	128	10	**6**
BEER	323	26	7	**4**

Selected Information Science Journals

Next, we show a similar table (Table 9) for some selected information science journals. Recall that we use a database that starts in 1955: some journals existed already before that date while others were established much later; for some journals, the database is not complete as only integrated from a certain year on. This, of course, influences the data shown in Table 9. ASLIB refers to the *ASLIB Proceedings* and the *ASLIB Journal of Information Management*; JASIS(T) refers to the *Journal of the American Society for Information Science*, the *Journal of the American Society for Information Science and Technology*, and the *Journal of the Association for Information Science and Technology*. ARIST stands for the *Annual Review of Information Science and Technology*; IPM stands for *Information Processing & Management*, JDOC for *Journal of Documentation*; JIS for Journal of Information Science; JOI for *Journal of Informetrics*; MJLIS stands for the *Malaysian Journal of Library and Information Science*, while TF&SC stands for *Technology Forecasting & Social Change*.

Table 9. h-Type Indexes for Selected Publications in the Information Sciences (data collected on September 18, 2018).

Journal title	**N**	**h**	**$h^{(2)}$**	**$h^{(3)}$**
ARIST	550	52	12	5
ASLIB	2,897	31	8	4
IPM	3,359	80	14	6
JASIS(T)	3762	122	19	8
JDOC	3,975	69	15	6
JIS	2,146	55	11	6
JOI	875	55	12	6
MJLIS	236	12	4	2
Research Evaluation	576	35	8	4
Scientometrics	5,465	98	16	6
TF&SC	4,765	86	13	6

CORRELATIONS BETWEEN H-TYPE INDICES

A correlation analysis between the h, $h^{(2)}$ and $h^{(3)}$-indexes was performed for a selection of 100 management journals selected half from the leading journals in the Financial Times Top 50, and half consisting of specialized journals in a few specific management sub-fields. The complete list is available from the authors. Table 10 shows the data of the sample with the average, maximum and minimum number of articles of these 100 selected publications, and similar data for the total number of citations of those publications, their h, $h^{(2)}$ and $h^{(3)}$-index. The h-index varied from 18 to 299; the $h^{(2)}$-index from 6 to 35 and the $h^{(3)}$-index from 2 to 13, while the average indexes were respectively 139, 19 and 8. The Pearson correlation (see Table 11) between h and $h^{(3)}$ is 0.952; it is 0.982 between $h^{(2)}$ and $h^{(3)}$, and 0.976 between h and $h^{(2)}$. These statistical correlations can be regarded as suggesting practical equivalence, but requiring a much shorter list of highly-cited publications for the determination of $h^{(3)}$. This observation illustrates why the $h^{(3)}$-index is of practical use when studying large amounts of data, such as journal articles collected over a relatively long period.

Table 10: Data Related to 100 Selected Management Journals

	N	**CIT**	**h**	**$h^{(2)}$**	**$h^{(3)}$**
Average	3,012	128,705	139	19	7.9
Max	8,567	488,759	299	35	13
Min	1,332	4,080	18	6	2

Table 11: Pearson Correlation Between h-Type Indices of 100 Selected Management Journals

	h	**$h^{(2)}$**	**$h^{(3)}$**
h	1	0.976	0.952
$h^{(2)}$		1	0.982
$h^{(3)}$			1

DISCUSSION

Step-wise Increases and the $h^{(3)}$-Index

The incremental increase to raise the $h^{(2)}$-index by 1 is much higher than for the h-index, and it becomes even higher to raise the $h^{(3)}$-index value by 1. To raise the level of the h-index from 10 to 11 demands on average 10% more citations, to raise the $h^{(2)}$-index from 10 to 11 requires an average increase of 21% citations; to raise a $h^{(3)}$-index of 10 to 11 needs 33% more citations. However, for a higher h-index value this increment (expressed in percentages) gradually decreases. The incremental increase in citations to bring the next stepwise increase is much more important in percentage and certainly in absolute numbers for $h^{(3)}$-indexes than for the $h^{(2)}$- and h-indexes, especially at the level of the highest categories.

A raise in $h^{(3)}$-index takes longer than for the other h-type indices. While the h-index increased by a factor of around 4 for *Scientometrics* and *SMJ* over the last 20 years, the $h^{(3)}$-index only doubled in that same period; and increased by a factor of 1.33 for *Nature*. However, the changes in absolute terms are even more important: the absolute increase of the h-index in the period 2000-2018 was 69, 202 and 592 This means an increase of the h-index 3 times, 20 and 30 times a year. Conversely the $h^{(3)}$-index of those journals increased by 3, 8 or 5 in absolute terms, which results in a change every 7, 2.5 or 4 years. Moreover, with the exponential increase of required thresholds, this time frame further augments. The higher the $h^{(3)}$-index, the longer it takes to reach the next threshold. Hence the $h^{(3)}$-index is more stable than the $h^{(2)}$- and the more volatile h-index.

The h-indexes of the major journals in bibliometrics approach the value 100; in management the h-index varies between 150 in entrepreneurship to 300 in general management. The field of medicine has much higher values (around 1,000). *Science* and *Nature* obtain an h-index above 1,200. The $h^{(2)}$-indexes range from 7 to 34 in management, 16 in bibliometrics, 60 in medicine, while *Nature* and *Science* reach the highest values among those shown here, with an $h^{(2)}$-index of 69.

With the increase of articles and citations, the selectivity of the h-index and $h^{(2)}$-index diminishes, and comparisons get more difficult. An h-index of 5 or 7 makes a difference, and certainly does an $h^{(2)}$-index of 7 or 9. However, whether the h-index is 140 or 150, or the $h^{(2)}$-index 33 or 35, is not really informative.

Advantage of the $h^{(3)}$-Index

The $h^{(3)}$-index offers a valuable alternative for ranking journals and is very simple to calculate from existing databases. It only necessitates the 15 to 30 most-cited articles of a journal in the database; this information is available in the Web of Science or other databases, whereas one cannot calculate the JIF factor, which depends on data only known to the database owner. Similar to the case of the h-index, the $h^{(3)}$-index can be calculated for individual scholars (with many publications), for a department or for a university. It better differentiates through a stepwise approach (which means that there are many ties so that one does not differentiate between similar journals) and is more selective than existing h and $h^{(2)}$-indexes. The statistical correlations between the h-, $h^{(2)}$- and $h^{(3)}$-indexes point to practical equivalence, at least when working in one field. Hence, for journals the $h^{(3)}$-index can be used instead of the h-index. The advantage of the $h^{(3)}$- index is that it can be determined from a much smaller set of top-cited articles. Even if the $h^{(3)}$-index has a lot of common with the h-index it is much more selective. The higher the $h^{(3)}$-index, the higher the number of citations received by articles in the $h^{(3)}$ core. In many datasets, the criteria for an $h^{(3)}$-index of 4 respectively 5, necessitate articles with 64 respectively 125 citations; this means that the $h^{(3)}$-core articles are generally situated in the 10 or 5% percentile of most cited articles; for an $h^{(3)}$-index higher than 7, they are generally in the top 1% of the dataset. The $h^{(3)}$-index thus indirectly incorporates the notion of highly cited publications, and by this, it produces more consistent rankings than the h-index.

The $h^{(3)}$-index requires only the 15 most cited articles (exceptionally some more as in the case of *Nature*), compared to 50 to 70 for the $h^{(2)}$-index and 500 to 1200 for the h-index. Consequently, a change in $h^{(3)}$-index has more meaning than a change in h-index. Finally, we recognize that all h-type indicators do not always behave in a logical way (Bouyssou and Marchant 2011; Waltman and van Eck 2012). Like many other indicators the $h^{(3)}$ indicator is only PAC (Probably Approximately Correct) (Rousseau 2016). Of course, as for the JIF, journals' $h^{(3)}$ values should not be used to evaluate individual researchers (Zhang et al. 2017).

The second-order h-indices as studied e.g. in Ye and Bornmann (2018) are briefly presented in the Appendix for the set of information sciences journals discussed in this paper.

CONCLUSION

Determination of a journal's $h^{(3)}$-index requires considerably less information, i.e. citations of the most-cited articles, than the h-index. As such its calculation needs considerably less time. A change in the value of an $h^{(3)}$-index has more meaning than a change in h-index. Moreover, thanks to its slow incremental increase, the $h^{(3)}$-index shows more stability. $h^{(3)}$-Indexes can be calculated for other datasets than for journals, e.g. institutions or countries and offer similar advantages in these cases too. The $h^{(3)}$-index thus produces more consistent rankings than the h-index. These rankings consist of tiers of journals with the same $h^{(3)}$-index, contrary to the fine-grained, but misleading, rankings based on the JIF.

The proposed $h^{(3)}$-index for journals offers an alternative for the rankings or classification of journals. Contrary to the more sophisticated indexes for journals such as the JIF and SJR-index, they can easily be calculated and do not depend on data only known to the database owner. As a suggestion for further research we propose to investigate the correlations between the $h^{(3)}$-index for journals and those contested indexes.

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APPENDIX

A Matrix of Different Types of h-Indices

Given a set of journals one can calculate their h-indices. Then it is possible to determine the h-index of this array of h-indices, leading to a second-order h-index (Ye and Bornmann 2018). Yet, one may also calculate the $h^{(2)}$-index and the $h^{(3)}$ - index of this array.

Similarly, given this set of journals one may calculate their $h^{(2)}$ or $h^{(3)}$ indices, leading to arrays of $h^{(2)}$ or $h^{(3)}$ indices. Then one may calculate the h-, $h^{(2)}$ – and $h^{(3)}$ - indices of these arrays. Although, only the h-index of h-indices, the $h^{(2)}$-index of $h^{(2)}$-indices and the $h^{(3)}$-index of $h^{(3)}$-indices seem (to some extent) useful, it is mathematically of interest to note that for the same data, the $h^{(k)}$-index of an array of $h^{(l)}$-indices is (in general) not equal to the $h^{(l)}$-index of an array of $h^{(k)}$-indices, with k, l = 1,2,3, … , see Table 12 for such examples. As an illustration we calculated those second-order values for Table 9, consisting of journals in the information sciences. The arrays of h-indices, $h^{(2)}$ - and $h^{(3)}$ – indices of journals are shown in Table 9. Now we calculate for these arrays their three types of h-indices. In the next matrix (Table A) each row gives the result of an h-index, $h^{(2)}$-index and $h^{(3)}$-index calculation, applied to each of the three arrays (one per column).

Table A: Matrix of Different h-Type Indices for the Data Shown in Table 9

	h	$h^{(2)}$	$h^{(3)}$
h-index of	11	8	6
$h^{(2)}$-index of	7	3	2
$h^{(3)}$-index of	4	2	1