Overcitation and overrepresentation of review papers in the most cited papers

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abstract

Review papers tend to be cited more frequently than regular research articles. This fact, together with the continuous increase of the share of reviews in scientific literature, can have important consequences for the measurement of individuals' research output, usually based on citation analysis. However, studies evaluating the differences in citations of review papers compared to original research articles are almost non-existing in the literature. This paper presents a thorough analysis of the overcitation and overrepresentation of review papers in the most cited papers of the 35 largest subject categories in Science Citation Index Expanded. Results indicate the average citations received by reviews depends largely on the research area considered, varying from 1.34 to 6.74 times the citations received by original research articles (average value is 2.95). Correlated with this overcitation, there is an important overrepresentation of reviews in the most cited papers, this overrepresentation being greater when the most highly cited papers are considered, i.e. 0.05% and 0.1% most cited papers, where the share of reviews have increased from 16 to 18% in 1990 to around 40% in 2010. Interestingly, the overcitation and overrepresentation in the most cited papers is more important in the areas with the lowest shares of reviews in total publications.

1. Introduction

Some types of publications such as editorials, letters to editors, news items, meeting abstracts, and case studies are generally poorly cited. On the contrary, review papers tend to be cited more frequently than original research papers and journals publishing reviews tend to have higher impact factors (Aksnes, 2003; Moed, 2010; Teixeira et al., 2013). Good reviews are very valuable for researchers, especially when they start working in a new area, as they assess critically and systematically the findings and approaches followed in the research area, summarizing and synthesizing the state of the research and pointing out future research needs. This can explain the higher citation rates for reviews, however, it is also true that reviews can sometimes be cited just because it is simply easier to cite a review than to read, understand, judge and sort the original data (Ketcham & Crawford, 2007; Teixeira et al., 2013).

The research output is one of the main factors considered to measure and evaluate the research performance of institutions and individuals (Jones and Evans, 2013). In the past, the number of publications and the impact factor of the journals in which those papers were published, were the main indexes to evaluate the scientific impact of research. At present, the number of citations received by the publications has gained great importance for evaluating research performance, i.e. the total number of citations of a given author, the average number of citations per paper, the h-index or more recently, the number of highly cited papers or ESI papers (top 1% most cited articles in Web of Science database by subject categories) (Aksnes, 2003; Ale Ebrahim et al., 2013; Teixeira et al., 2013; Foley, 2013; Waltman, 2016). An advantage of these metrics is that they evaluate directly the author's work instead of using the impact factor of the journals where scientists published their works. However, there are also some biases associated to the number of citations received, which question if they express impartially one's scientific research impact (Teixeira et al., 2013). Citation rates, for example, differ largely according to research areas. Wider science journals and fundamental science journals appear also to have greater citations than do journals of specialized or applied subject areas (Foley, 2013). Citation rates also vary according to whether or not the journal is open-access, freely accessible papers generally gathering more citations (Foley, 2013).

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In Spain, for example, there is a growing number of calls for research programmes or to apply positions in the universities which include bibliometric criteria based on citation counts. For example, in the call "Support to Excellence Centres Severo Ochoa and Excellence Units María de Maeztu" (2017), the scientific director as well as at least 10 other participating researchers must have a normalized impact greater than 1.5 compared to world average in their research areas, i.e. having 1.5 times more cites than the average in their research areas. The same criterion was used for the promotion of researchers outstanding by international merits in Complutense University of Madrid (2017 and 2018). In this call, there were three situation to be promoted: a) the researchers will promote to associate professor if they obtained a starting ERC grant and to full professor if they obtained a consolidator ERC grant; b) to be the only coordinator of an European project from H2020 programme and also comply with c); c) researchers having in the last five years a normalized impact greater than 1.5 compared to average world in their research areas. In both cases, the list of world average citations by research areas was supplied by ad-hoc lists created by WoS by order of the Spanish Foundation for Science and Technology (FECYT). Regarding the importance of citation counts and other bibliometric measurements of individuals, it is also interesting to comment how the CV of researchers is presented to evaluators in the two main Spanish R&D programmes: the "National Programme for Research Aimed at the Challenges of Society" (243.9 million euros) and the "National Programme for Fostering Excellence in Scientific and Technical Research (125.5 million euros) (2017 budget). In both calls, a 30% of the grade is obtained by the "quality, trajectory and adequacy of the research team". This grade is based on "shortened" version of the CV (4 pages maximum) of the members of the research team. Again the first thing in this CV (after personal data and ResearchID or ORCID identifiers), is a compilation of the general indicators of the quality of scientific production (bibliometric indicators). All researchers should include the following indicators: total cites, average citations per year during the last 5 years, total publications in quartile 1 (Q1) and h-index. These bibliometric indicators clearly impact their evaluation.

Previous studies have demonstrated important increases of the share of reviews in total publications in different research areas (Harzing, 2013; Royle, Kandala, Barnard, & Waugh, 2013). The share of reviews in Oncology, for example, increased from less than 1% in 1991 to around 4.5% in 2011 (Colebunders, Kenyon, & Rousseau, 2014), and the number of review articles in Pathology have increased 2.4 times greater than the number of regular research articles in the period 1991–2006 (Ketcham & Crawford, 2007). The increasing share of reviews in the scientific literature can have important consequences in measuring individuals' research output. First, although reviews can bring works to attention of researchers, the reviews can also affect also the number of citations received by the original sources as the original sources are not credited when review papers are being cited (Aksnes, 2003). Authors who originally had an idea have a greater chance of being neglected when their articles are referred to in a review (Teixeira et al., 2013), "the kiss of death?" as questioned by Lachance, Poirier, and Larivière (2014). Furthermore, these "lazy citations" introduce positive biases toward authors of the reviews (Teixeira et al., 2013).

Second, the larger number of citations received by reviews compared to original research articles may mask the research quality of individuals publishing many reviews. Many studies have concluded the authors aiming to obtain the greatest citations should write comprehensive and substantial review articles and submit them to journals with a high impact factor (Ale Ebrahim et al., 2013; Vanclay, 2013). Nevertheless, it appears as a counterproductive implication that to become highly cited one should write review articles instead of producing new original research (Aksnes, 2003; Vanclay, 2013). The problem will arise if some people could focus on writing review papers instead of original research papers as this is one of the fastest ways to get recognition and improve their citation indexes. Furthermore, it is well known the average number of citations of a set of publications may be strongly influenced by one or a few highly cited publications (Haustein, 2012; Waltman, 2016; Wilson, 2016). Although other citation indicators could avoid this situation, i.e. the geometric mean of citations, they are not widely used.

The continuous growth in the share of reviews in scientific production is not only a question of the authors, the citation rates have clear implications for the journals, as a way to increasing journal visibility and impact factor (Ketcham & Crawford, 2007). In fact, review papers are viewed by many editors as a mechanism to "drive the impact factor" (Ketcham & Crawford, 2007).

The question must therefore be asked: have we reached a point where there is now an unmanageable quantity of review articles? If so, is the review literature serving its intended purpose? (Ketcham & Crawford, 2007). Although review papers are considered to be general indicators of quality in scientific production, they can be also considered, especially the bad ones, only as assortments of information which do not represent new or "real" scientific contribution (Aksnes, 2003; Teixeira et al., 2013). These facts could be considered as a problem for using citations as performance indicators, which is augmented by the fact that the review papers are also the highest cited (ESI papers, highly cited papers, etc.) (Aksnes, 2003). Based on responses to a questionnaire sent to Norwegian researchers in different science fields, Aksnes (2006) found that even researchers felt that the value of their reviews were overestimated in terms of citations.

As recognized by Wilson (2016), it is clear that original research articles should be always included in bibliometric analysis. However, publications of other document types, such as "editorial material", "letter" and "review" may be either included or excluded. Aksnes (2003) already suggested that if possible, such papers should be excluded from citation analysis at lower aggregate levels or at least, relative citation indicators would be considered for different types of publications. Similarly, Vanclay (2013) stated it could be of interest to discriminate review articles from other contributions (articles and conference papers) in citation analysis.

Although some studies have already shown the problem of the higher citation rates of reviews compared to original papers in evaluating scientific research, the number of studies is very limited. There is a lack of systematic studies analyzing exactly what is the overcitation of these papers and how important this fact is depending on the research area concerned. Thus, the objective of this article is to analyze the different citation rates of reviews, compared to total publications and articles, and its overrepresentation in the most cited publications in different research areas, as well as their evolution with time. This analysis aims to obtain sufficient quantitative data to serve as a basis for discussing whether review articles should be taken into account jointly or not with original research articles in citation analysis.

2. Methodology

Scientific production by document types has been analyzed through the Web of Science® Core Collection database. Web of Science (WoS) is an on-line service for scientific information, developed by the Institute for Scientific Information (ISI), and now owned by Clarivate Analytics. WoS facilitates the access to a set of bibliographic databases from different areas which includes publications on Science (Science Citation Index), Social Sciences (Social Sciences Citation Index) and Art and Humanities (Arts and Humanities Citation Index).

Present study focused in the area of Sciences through the analysis of the records from Science Citation Index Expanded (SCI-E) database. General trends have been obtained for all the publications covered by SCI-E, while specific studies have been circumscribed to the 35 largest subject categories in terms of publications during the period 2000–2015, these categories representing a 64.3% of total publications in this period in SCI-E (14,251,769 publications of 22,177,480).

Number of citations received by the different document types and the selection of the most cited papers were carried out based on the citation counts obtained in WoS database at July-August 2016. In all the cases, documents were sorted from the highest to the lowest times cited, and downloaded to get the desired classes of the most cited papers. Although ESI indicators such as "highly cited papers" or "hot papers" are very useful for a quick reference value for most cited papers, they were not used in this study for a variety of reasons. First of all, ESI indicators are based on 22 ESI subject areas which combines several WoS categories (there is a total of 251), thus an important information on specific research areas are lost because they are grouped in a single ESI category. Second, the period of time to be analyzed cannot be selected, ESI indicators are always calculated from the most recent 10 years of publications in the case of “highlycitedpapers”andfromthemost recent2yearsofpublicationsinthecaseof“hotpapers”,whichisaclearlimitationfortheanalysisoftheevolutionwith time.Finally,onlytwodocumenttypesareconsideredbyESIindicators(originalresearcharticlesandreviewpapers),thus documentswithgreaternumber ofcitationsareexcludedifthey arenotassignedto oneofthesedocumenttypes.Asstated byWoS:“Althoughhighlycitedpapersaresynonymouswith% documentsinthetop1%inInCites®,theyarenottheidentical becauseofdifferencesinsubjectscheme,timeperiodanddocumenttype”.

Reviewpaperscanbedefinedasthosepapersbasedonotherpublishedarticleswithoutreportingoriginalresearch, generallysummarizingtheexisting literatureonatopicinanattempttoexplainthecurrentstateofunderstandingonthe topic.However,inrealpractice,theassignmentofadocumentasareview paperisnoteasyascouldbethought.Eventhose whoprofessionallycatalogarticlesdonotalwaysagreewhatconstitutesareview.Furthermore,sometimes journaleditors donotagreewithWoSorScopustowhichoftheirjournalpapersarereviewarticles(Ketcham&Crawford,2007).

Thisstudyfocusedonreviewpapersclassifiedassuchin WoS.BeforeFebruary2010,WoScategorizedapublishedpaper asareviewinthesepragmatic terms: (a)ifit has more than 100 references; or (b) ifit appears in a review journal or the review section of a research journal; or (c) ifthe paper states in the abstractthatitisareview(Ketcham&Crawford, 2007).OnFebruary2010,therewasapolicychangeanddocumentshaving100ormorereferenceswerenot furtherclassified automaticallyasreviews.Ascriticizedbysomeauthors,therewereasignificantamountoforiginalresearcharticlesincluding over100 referenceswhichwereclassifiedasreviews,especiallyinSocialSciences(Harzing,2013).

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Table1
DocumenttypesofthepublicationscoveredbySCI-Eduringtheperiod2000–2015.

Rank	Documenttype	No.documents	%Totalpublications
1	Article	15,661,692	70.64
2	MeetingAbstract	3,369,168	15.20
3	ProceedingsPaper	1,091,627	4.92
4	EditorialMaterial	1,049,457	4.73
5	Review	856,072	3.86
6	Letter	613,717	2.77
7	NewsItem	331,657	1.50
8	Correction	162,432	0.73
9	BiographicalItem	60,731	0.27
10	BookReview	54,800	0.25
11	BookChapter	33,346	0.15
12	Reprint	7,523	0.03
13	SoftwareReview	1,902	0.01
14	Bibliography	1,257	0.01
15	Others	326	0.00
	Sum	23,295,707	105.07
	Total	22,170,709	100.00

forexample,foundinapreliminarystudythatprecisionforreviewsassignmentwasaround91%inWoScomparedto67%in Scopus(publicationyearsofthe samplewasnotspecificed).Inamorecomprehensiveanalysiswithupdateddata,Donner (2017)foundtheprecisionforreviewsassignmentwas87%inWoS and82% in Scopus for a random sample of documents published between 2002 and 2014. Excluding the results for journals which were not statistically significant, Harzing (2013) found in Science areas such as Neurosciences or Chemistry, the average misclassification was similar, at around 8–10% for paperspublishedbetween2001and2011inWoS.Thesituationwas,however,verydifferentinSocialScienceswherethe misclassificationwasmuchhigher (see Harzing, 2013 for a detailed discussion). Thus, according to the literature, we consider the analysis of the assigned reviews in SCI-E from WoS is representativeenoughofthereviewpapers. 3.Resultsanddiscussion 3.1.Documenttypes

ThenumberofdocumentsincludedineachdocumentclassinSCI-Eduringtheperiod2000–2015isshowninTable1. Although WoS defines 39 document classes, almost all documents can be assigned to one of the seven first document types (article, meeting abstract, proceedingspaper, editorial material, review, letterandnews item)(98.73%oftotalpublications, 21,888,355publications),therestofcategorieshaving percentages lower than 1% total publications. “Others” (326 publications, 0.0015%) are comprised mainly by hardware review (139), database review (112),book(26),meetingsummary(14) andmaincite(10).

InWoS,publicationscanbeassignedtomorethanonedocumenttypeandthecalculationofthenumberofdocuments ineachdocumenttypeattributesone fullpointtoeachdocumenttypeinthecaseofpublicationsassignedtotwodifferent documenttypes.Thisisthereasonwhythesumofallthepublicationsin eachcategoryismorethan1milliongreater thanthetotalnumberofpublications.Mostofthisdifferenceiscausedbythedoubleassignmentof“Proceedings

Paper" as "Article" and "Proceeding Paper". In fact, all the "Proceedings Papers" are also categorized as "Article". This justifies 1,091,627 from the 1,124,998 difference in publications (97.03%). The main other double assignment occurred in "Review":
23,631 publications were classified as "Review" and "Book chapter" and other 10 as "Review" and "Book", and in "Editorial Material", where 1302 publications were classified simultaneously as "Editorial Material" and "Book Chapter". There are no double assignment, however, in "Meeting Abstract" or "News Item", while it is negligible in "Letter", "Correction" or "Biographical Item" document types.

Reviews is the fifth document type in terms of the number of publications: 856,072 documents (3.86%). However, there are marked differences in the share of reviews from total publications among research areas. Fig. 1 shows the accumulated distribution curve of the share of reviews in total publications for the 177 SCI-E subject categories. The share of reviews in total publications varied from 0.00% ("Public Environmental Occupational Health") to 20.04% ("Rehabilitation"), the first quartile being 1.48%, the median being 3.53% and the third quartile being 5.75%.

Table 2 shows the total number of publications (TP), the number of reviews (R) and the share of reviews in total publications (%R) of the 35 largest subject categories in terms of publications. In this case, an average 4.25% of the publications were reviews. This value is greater than the median share of reviews in the 177 SCI-E subject categories due to some of the largest areas in terms of total publications are those with the highest shares of reviews, i.e. "Pharmacology Pharmacy" (10.89% of total publications are reviews), "Cell Biology" (7.71%), Biochemistry Molecular Biology (7.52%), "Medicine Research Experimental" (7.13%), "Microbiology" (6.60%), "Neurosciences" (6.10%) and "Biotechnology Applied Microbiology" (5.91%). On the other hand, the research areas with the lowest share of reviews are "Mathematics" (0.14%), "Engineering Electrical Electronic" (0.47%), "Optics" (0.70%) and Physics Applied (1.24%).

Fig. 1. Accumulated distribution curve of the share of reviews in total publications for the 177 SCI-E subject categories.

Table 2
Total publications (TP), reviews (R) and share of review papers in total publications (%R) for the 35 largest subject categories in SCI-E in the period 2000–2015.

	Subject category	TP	R	%R
1	Biochemistry Molecular Biology	1,072,096	80,615	7.52
2	Chemistry Multidisciplinary	942,339	31,367	3.33
3	Materials Science Multidisciplinary	878,802	13,124	1.49
4	Oncology	804,458	46,015	5.72
5	Neurosciences	758,771	46,284	6.10
6	Chemistry Physical	700,163	12,545	1.79
7	Surgery	686,415	24,766	3.61
8	Physics Applied	683,740	8464	1.24
9	Pharmacology Pharmacy	683,391	74,405	10.89
10	Clinical Neurology	658,529	35,551	5.40
11	Engineering Electrical Electronic	645,243	3032	0.47
12	Cell Biology	607,926	46,853	7.71
13	Medicine General Internal	581,318	38,037	6.54
14	Cardiac Cardiovascular Systems	556,107	20,043	3.60
15	Immunology	492,543	36,311	7.37
16	Multidisciplinary Sciences	483,147	7985	1.65
17	Environmental Sciences	461,594	13,922	3.02
18	Physics Condensed Matter	428,162	5,928	1.38
19	Endocrinology Metabolism	412,139	23,674	5.74
20	Gastroenterology Hepatology	406,012	15,705	3.87
21	Engineering Chemical	400,926	5,559	1.39
22	Biotechnology Applied Microbiology	397,459	23,507	5.91
23	Hematology	383,572	15,029	3.92
24	Radiology Nuclear Medicine	376,664	11,688	3.10
25	Genetics Heredity	357,300	20,035	5.61
26	Psychiatry	352,287	17,468	4.96
27	Physics Multidisciplinary	345,537	6784	1.96
28	Peripheral Vascular Disease	342,381	11,715	3.42

29	Medicine Research Experimental	340,662	24,278	7.13
30	Public Environmental Occupational Health	338,500	11,205	3.31
31	Plant Sciences	332,681	16,364	4.92
32	Optics	324,540	2260	0.70
33	Mathematics	320,518	448	0.14
34	Chemistry Organic	317,110	10,604	3.34
35	Microbiology	307,360	20,297	6.60
	Sum	18,180,392	781,867	4.30
	Total	14,251,769	606,149	4.25

3.2. Share of reviews evolution with time

While the number of publications in SCI-E increased 2.7-fold from 1990 (690,675) to 2015 (1,864,822), the number of review papers increased 5.3-fold, from 14,804 to 79,033 reviews (Fig. 2). The share of reviews in total SCI-E publications has increased continuously in the last 25 years, from 2.14% in 1990 to 4.39% in 2015 (average 3.86%). In 1990, a review was published per 34.2 original research articles, while at present (2015), a review is published per 16.8 articles.

The increase in the share of reviews in total publications slowed down after 2009 and maintained almost constant at around 4.0–4.5% up to 2015, probably due to WoS policy change for reviews assignment. However, newest data shows the previous trend has recovered and the share of reviews increased significantly in the last two years: 4.7% in 2016 and 5.1% in 2017 (see Fig. S1, Supplementary information).

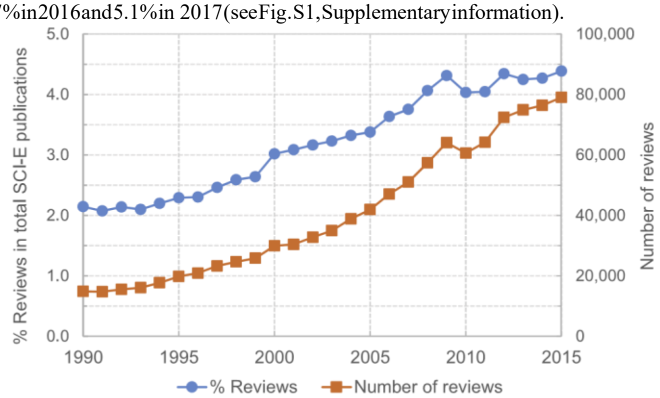

Fig. 2. Evolution of the number of reviews and reviews share in SCI-E publications (177 subject categories) from 1990 to 2015.

A previous study focused on Social Sciences Index also found for nearly all the journals of this category the year with the largest number of reviews was either 2008 or 2009, and after 2009, the proportion of review articles declined dramatically (Harzing, 2013). This is easily explained by the change in WoS policy for reviews assignment and the larger proportion of original research articles with 100 or more references which were assigned to review papers compared to Sciences. This made the effect of this policy change much larger in Social Sciences than in Sciences, in fact, the share of reviews in Social Sciences decreased drastically from 3.6% in 2009 to 2.5% in 2010 and the 3.6% share of reviews has not been recovered until year 2016 (see Fig. S1, Supplementary material).

3.3. Citation rates of reviews by research areas

To assess the degree in which reviews are more often cited than other document types and articles, the average citation per document type of the 35 largest subject categories of the SCI-E in the period 2000–2015 were analyzed. The average citation of review papers (AC-R) was compared to the average citations received by all document types (AC) and average citations received by original research articles (AC-A) through the ratio AC-R/AC and AC-R/AC-A, respectively (see Fig. 3). This analysis was carried out at three different publication years (2000, 2005 and 2010) and the values presented in Fig. 3 are the average values from the three years (detailed data in Table S1, Supplementary material).

AC-R/AC-A was always lower than AC-R/AC primarily because the important share of meeting abstracts in some research areas. Meeting abstracts is the second document type in terms of publications but this is poorly cited; in the present study, it was found that 93.6% of the meeting abstracts were never cited. On average, the AC-R/AC ratio for the 35 largest subject categories was 3.64 while the ratio AC-R/AC-A was 2.95. This means review papers were cited, on average, 3.64 times for than the average for total publications (all document types) and 2.95 times more than regular articles.

There are large differences among areas: AC-R/AC ratio varied from 1.96 to 7.39, depending on the research area, and AC-R/AC-A, from 1.34 to 6.47. There are areas in which the overcitation of review papers is the greatest (AC-R/AC > 4 or ACR/A > 3.5) such as "Engineering Electrical Electronic", "Chemistry Multidisciplinary", "Physics Applied", "Materials Science Multidisciplinary", "Engineering Chemical", "Physics Condensed Matter", "Physics Multidisciplinary", "Optics", "Endocrinology Metabolism", "Chemistry Physical" and "Plant Sciences". The areas in which the overcitation of reviews is the lowest (AC-R/AC < 2.5 or AC-R/A < 2) are "Oncology", "Radiology Nuclear Medicine", "Surgery", "Mathematics", "Medicine Research Experimental", "Biochemistry Molecular Biology", "Pharmacology Pharmacy" and "Medicine General Internal".

Colebunders et al. (2014) found for papers published in WoS during the period 2000–2011 in the fields of "Oncology" and "Infectious Diseases" that reviews were cited (on average) about 70% more often than were "normal" articles (ACR/AC-A = 1.7), while in "Tropical Medicine", reviews were cited twice as much (AC-R/AC-A = 2). In the present study, neither "Tropical Medicine" nor "Infectious Diseases" research areas were analyzed but "Oncology" was. The overcitation obtained for "Oncology" in the present study was very similar to that found by Colebunders et al. (2014), i.e. 1.61 vs. 1.7. However, Oncology is one of the research areas with the lowest value of overcitation of the 35 research areas analyzed. Hou, Li, and Niu (2011) investigated 14,537 articles and 2580 reviews published in the categories of "Biochemistry & Molecular Biology" and "Genetics & Heredity" during the years 2006–2007 in WoS and determined the number of received citations in the year 2008. They found that, on average, review papers were cited 1.64 times more frequently than articles. However, in the present study, AC-R/AC-A was significantly higher: 1.97 for "Biochemistry & Molecular Biology" and 2.61 for Genetics & Heredity. These higher values could be explained by the fact that citations were counted in shorter periods since publication than in the present study. As will be demonstrated later, the difference in citations between review and original research papers is greater at longer times elapsed since publication to the time when citations are counted.

Results obtained indicate that the research areas in which the actual share of reviews is the lowest, the overcitation is the greatest, and vice versa (see Fig. 4). This could indicate that some research areas "oversaturated" with review papers, these reviews being less well cited than in other research areas where the share of reviews is lower. However, another alternative

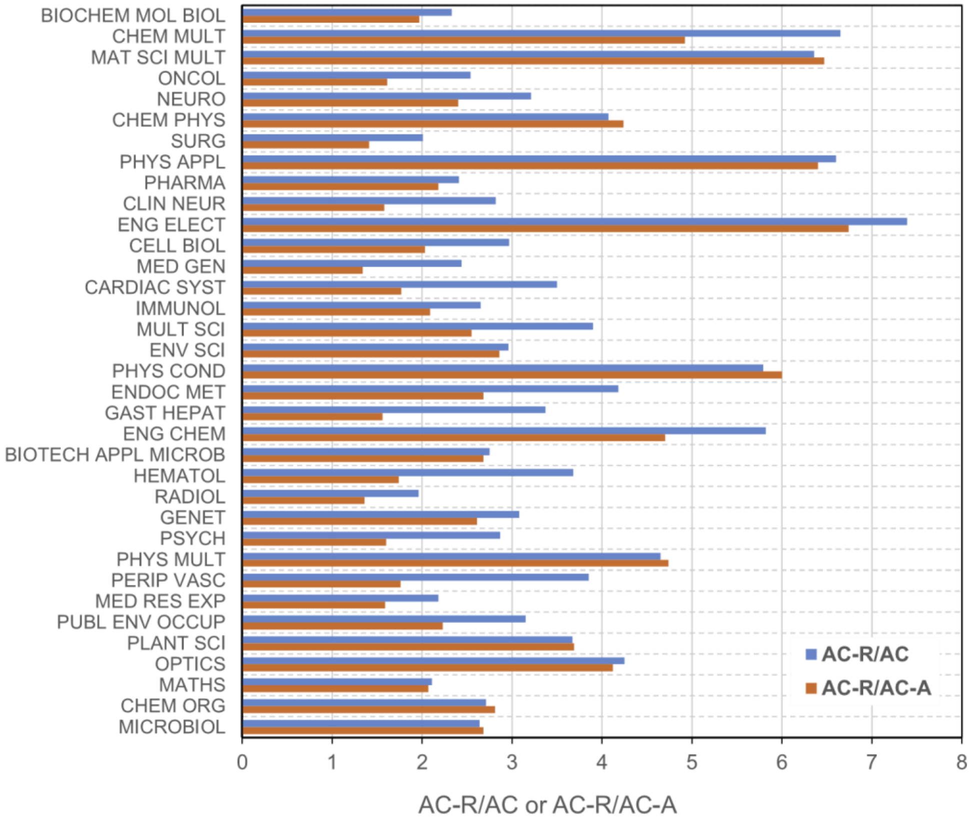

Fig. 3. Ratio AC-R/AC (average citations of reviews by average citations of all document types) and ratio AC-R/AC-A (average citations of reviews by average citations of original research articles) by subject categories.

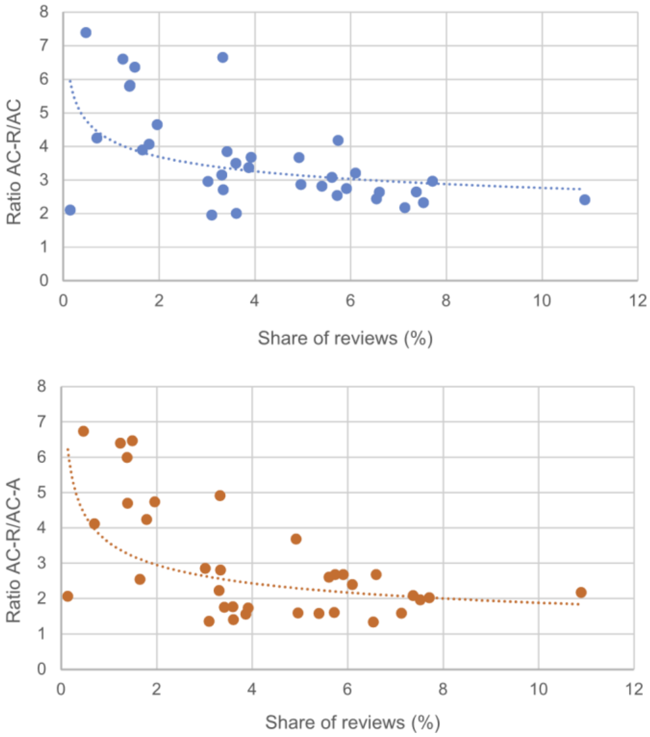

Fig. 4. (a) Ratio AC-R/AC (average citations of reviews by average citations of all document types) and (b) ratio AC-R/AC-A (average citations of reviews by average citations of original research articles) vs. % reviews in the research area.

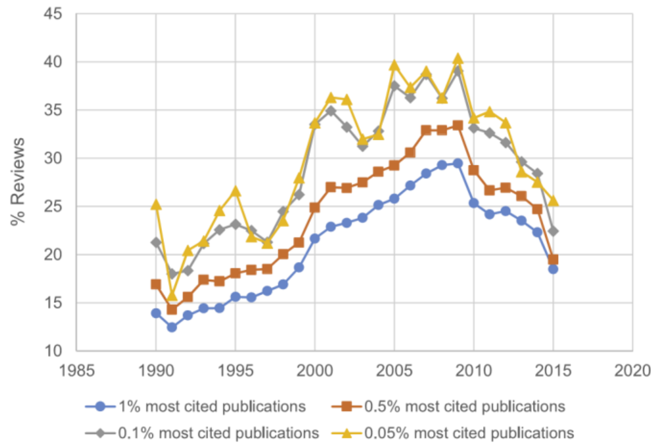

Fig. 5. Evolution of the share of reviews in the most cited publications in SCI-E (1990–2015).

point of view is also valid, there is not an "oversaturation" in areas with many reviews but a review deficiency in the areas in which the reviews are highly cited.

On the other hand, the areas in which the overcitation of reviews is the lowest (AC-R/AC < 2.5 or AC-R/A < 2) are "Oncology", "Radiology Nuclear Medicine", "Surgery", "Mathematics", "Medicine Research Experimental", "Biochemistry Molecular Biology", "Pharmacology Pharmacy" and "Medicine General Internal".

3.4. Share of reviews in the most cited papers evolution with time

Fig. 5 shows the percentage of reviews in the 1%, 0.5%, 0.1% and 0.05% most cited papers evolution with time in the whole SCI-E (not restricted to the 35 largest research areas). As observed, there is a very important share of reviews in the most cited papers and this share is greatest at the highly cited papers. The share of reviews in the 1% top cited papers increased from 12.4% in 1991 to 29.5% in 2009 and then decreased to 18.5%. In 0.5% top cited papers, the share of reviews was higher, increasing from 14.3% in 1991 to 33.4% in 2009 and then down to 19.5%. Furthermore, the share of reviews for 0.1% and 0.05% most cited papers were the greatest, with very similar values: in 0.1% top cited papers, it increased from 18.0% in 1991 to 39.1% in 2009 and then down to 22.4% in 2015; the share in 0.05% most cited papers increased from 15.8% in 1991 to 40.4% in 2009 and then down to 25.6% in 2015. Although the greatest increases in the share of reviews were observed from top 1% to top 0.5% and top 0.1%, the share of reviews in the 0.05% most cited was slightly greater than at 0.1% most cited (an average 3.2% greater), confirming the validity of the observed trends (also confirmed by data from Table 3). SCI-E (1990–2015).

As the share of reviews in total publications has almost doubled in the period analyzed (see Fig. 2), the overrepresentation of review papers in the most cited papers were also calculated (Fig. 6). This overrepresentation is defined as the ratio between the percentage of reviews in the most cited papers and the percentage of reviews in total publications. Trends observed in overrepresentation were similar to the share of reviews in the most cited papers, however, the overrepresentation increased in a lower extent than the share of reviews. This indicates the share of reviews in the most cited papers is largely affected by the important increase in the share of reviews in total publications. On average, the overrepresentation of reviews was 6.6 in 1% most cited papers, 7.6 in 0.5% most cited papers, 9.2 in 0.1% most cited papers and 9.5 in 0.05% most cited papers.

In both cases, the percentage of reviews among the most cited papers and the overrepresentation of reviews in the most cited papers, a sharp decrease occurred at around 2008–2010. This is primarily explained by the different citation patterns of original research articles and review papers. In general, original research articles have a greater immediacy than review papers, with citation peak observed around three years after publication, while the citation of reviews slowly rise to the peak many years after publication (Amin & Mabe, 2014). The cited half-life of review papers is greater than original research articles, with citations declining slowly after the peak, opposite to original research papers, with an important decline of citations after the peak is observed (Amin & Mabe, 2014). Consequently, as commented before, differences in citations received by reviews and original papers are lower when the citations are evaluated at shorter times after publication and greater at longer times.

Fig. 7 shows the citation curves for reviews and articles published in 2000 (citation numbers obtained from SCI-E in August 2017). The curve for reviews includes all the reviews published in 2000 (30,005 publications) while the curve for articles is a representative sample of articles published in 2000 (189,984 publications, i.e. 26.6% of the 715,004 total articles published this year).

As can be observed in Fig. 7, the original research articles received a larger share of citations in the first years since publication and a greater decline after reaching the citation peak compared to review papers. This turns into an AC-R/AC-A ratio which increases with years since publication at which the number of citations is counted. In this case, AC-R/AC-A varied

3
Shareofreviewsinthemostcitedpapers.

	Researchareas	Top1%	Top0.5%	Top0.1%	Top0.05%	Top0.01%
1	BiochemistryMolecularBiology	28.4	31.4	33.9	33.8	30.8
2	ChemistryMultidisciplinary	34.2	42.3	59.9	65.8	67.0
3	MaterialsScienceMultidisciplinary	15.2	19.7	30.9	36.0	46.6
4	Oncology	25.3	29.8	38.1	43.2	38.3
5	Neurosciences	32.7	37.9	53.1	57.3	54.0
6	ChemistryPhysical	16.2	20.5	30.1	33.1	38.6
7	Surgery	9.9	11.1	13.9	15.2	14.5
8	PhysicsApplied	13.0	17.5	29.0	33.6	48.5
9	PharmacologyPharmacy	51.2	59.1	74.1	78.4	83.8
10	ClinicalNeurology	21.3	24.4	29.8	33.5	40.9
11	EngineeringElectricalElectronic	5.3	7.4	10.7	12.1	10.8
12	CellBiology	32.1	36.4	44.8	47.4	65.6
13	MedicineGeneralInternal	18.3	17.8	13.3	11.0	6.9
14	CardiacCardiovascularSystems	16.4	18.8	25.0	31.3	32.1
15	Immunology	31.3	34.7	48.1	55.5	71.4
16	MultidisciplinarySciences	11.1	13.9	22.7	26.6	35.4
17	EnvironmentalSciences	22.4	26.7	38.1	44.2	60.9
18	PhysicsCondensedMatter	14.1	18.4	27.3	31.8	44.2
19	EndocrinologyMetabolism	29.5	32.4	42.5	40.8	34.2
20	GastroenterologyHepatology	17.8	20.2	25.6	29.6	43.9
21	EngineeringChemical	17.9	24.5	42.9	48.3	60.0
22	BiotechnologyAppliedMicrobiology	30.1	33.2	28.2	27.8	5.0
23	Hematology	20.6	23.9	31.5	40.1	47.4
24	RadiologyNuclearMedicine	10.7	13.0	17.8	17.0	13.2
25	GeneticsHeredity	32.3	35.3	33.6	32.4	16.7
26	Psychiatry	22.4	26.3	35.2	38.1	34.3
27	PhysicsMultidisciplinary	17.2	22.7	38.4	43.9	54.3
28	PeripheralVascularDisease	17.0	19.3	25.2	29.4	35.3
29	MedicineResearchExperimental	15.3	14.8	15.5	18.8	29.4
30	PublicEnvironmentalOccupationalHealth	18.1	20.6	24.8	24.9	23.5
31	PlantSciences	38.2	45.5	59.5	63.3-	73.5
32	Optics	8.0	11.5	23.4	27.8	33.3
33	Mathematics	1.1	1.6	2.5	3.8	6.3
34	ChemistryOrganic	27.7	36.2	55.5	61.0	81.3
35	Microbiology	42.1	48.2	59.1	59.7	51.6
	Average	21.8	25.6	33.8	37.0	41.0

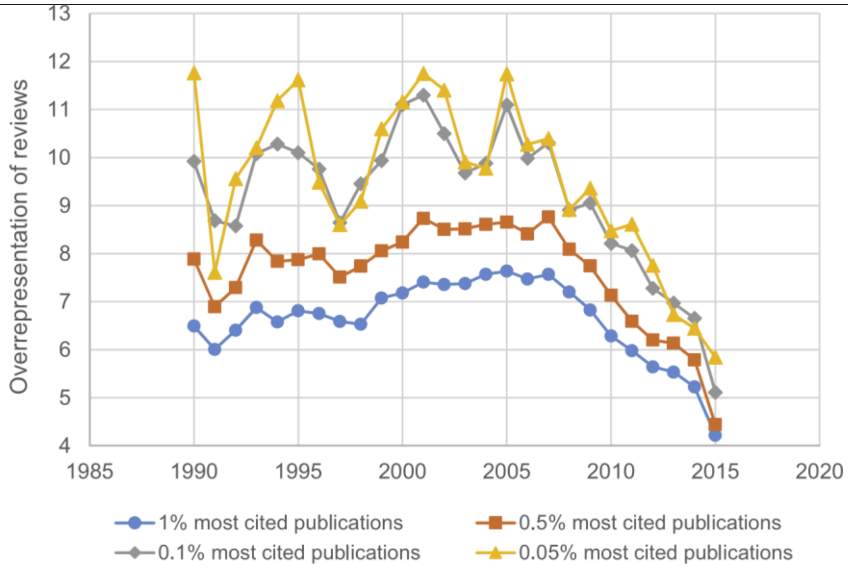

Fig.6.Evolutionoftheoverrepresentationofreviewsinthemostcitedpublicationsin SCI-E(1990–2015).

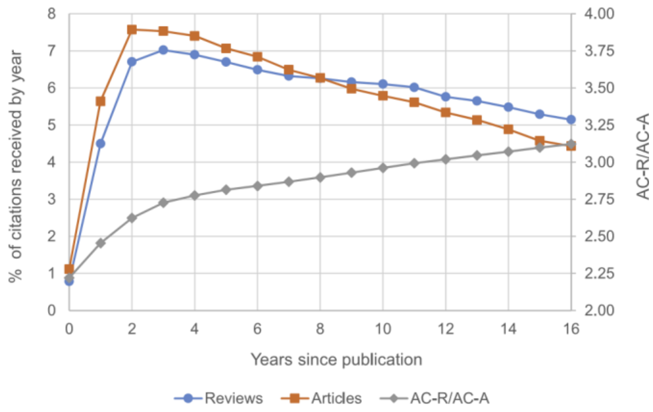

Fig. 7. Citation curves for articles and reviews published in 2000 and ratio AC-R/AC-A.

from 2.20 when citations were evaluated the first year after publication to 3.13 if the citations are counted 15 years since publication.

3.5. Share of reviews in the most cited papers by research areas

The share of reviews in the most cited papers of the 35 largest research areas of SCI-E in the period 2000–2015 is shown in Table 3. As previously commented, the share of reviews in the most cited papers is greater when the most highly cited papers are considered. Reviews represented, on average, 21.8% of the 1% most cited papers, 25.6% of the 0.5% most cited papers, 33.8% of the 0.1% most cited papers, 37.0% of the 0.05% most cited and 41.0% of the 0.01% most cited papers. Although the number of papers included in the 0.01% most cited paper is statistically questionable (from 31 to 107 papers, depending on the research area), the same trend was observed.

Again, there are large differences among areas. There are research areas such as "Chemistry Multidisciplinary", "Neurosciences", "Pharmacology Pharmacy", "Immunology", "Neurosciences", "Plant Sciences" and "Microbiology" with reviews representing 30–50% of the 1% most cited papers and 50–75% of the 0.1% most cited papers. Among them, "Pharmacology Pharmacy" is the area with the highest share of reviews in the most cited papers (51.2% in the top 1% and 74.1% in the top
0.1% most cited papers). On the other hand, there are areas in which the share of reviews is much lower. For example, in "Surgery", "Engineering Electrical Electronic", "Radiology Nuclear Medicine", "Medicine Research Experimental" and "Mathematics" reviews only represented 1–15% of the 1% most cited papers and 2–18% of the 0.1% most cited papers. In this case, "Mathematics" stands out as the area in which the share of reviews in the most cited papers is the lowest (1.1% in top 1% and 2.5% in top 0.1% most cited papers).

Obviously, the share of reviews in the most cited papers depends largely on the actual share of reviews in total publications (see Fig. S2, Supplementary material). For this reason, the overrepresentation of review papers in the most cited papers, defined as the ratio between the share of review papers in the most cited papers and the share of review papers in total publications, was also calculated for the different research areas (Table 4). The areas with the highest overrepresentation, i.e. >10 in top 1% and >20 in top 0.1% most cited papers are "Chemistry Multidisciplinary", "Materials Science Multidisciplinary", "Chemistry Physical", "Physics Applied", "Engineering Electrical Electronic", "Physics Condensed Matter", "Engineering Chemical", "Physics Multidisciplinary", "Optics", "Mathematics" and "Chemistry Organic".

Interestingly, there are research areas with the largest shares of reviews in the most cited papers but with some of the lowest values of overrepresentation. This means the high share of reviews found in the most cited papers is mainly explained by the high share of reviews in total publications and only partially by the greater number of citations of reviews compared to research articles. With the exception of "Chemistry Multidisciplinary" and "Chemistry Organic", both with high share of reviews in the most cited papers and high values of overrepresentation, this is the case for the rest areas with the highest share of reviews in the most cited papers: "Neurosciences", "Pharmacology Pharmacy", "Immunology", "Plant Sciences" and "Microbiology". In these areas, reviews represented, on average, 39.1% and 58.8% of the 1% and 0.1% most cited papers, respectively, however, overrepresentation was lower than the average: 5.7 and 8.6 for 1% and 0.1% top cited papers, respectively.

On the contrary, there are research areas with low to intermediate shares of reviews in the most cited paper but with some of the greatest overrepresentation values such as "Materials Science Multidisciplinary", "Chemistry Physical", "Physics Applied", "Physics Condensed Matter", "Engineering Chemical", "Physics Multidisciplinary" and "Optics". In these areas, the average share of reviews in 1% and 0.1% most cited papers is below the average, 14.5% and 31.7%, respectively. However, the average overrepresentation is greater than the average: 10.4 and 23.5, respectively. In these areas, there is an intermediate production of reviews but they are well cited. "Engineering Electrical Electronic" and "Mathematics" were most extreme examples of this behavior. They have the lowest share of reviews in the most cited but some of the greatest values of

4

Overrepresentation of review papers in the most cited papers.

	Research areas	Top 1%	Top 0.5%	Top 0.1%	Top 0.05%	Top 0.01%
1	Biochemistry Molecular Biology	3.8	4.2	4.5	4.5	4.1
2	Chemistry Multidisciplinary	10.3	12.7	18.0	19.8	20.1
3	Materials Science Multidisciplinary	10.2	13.2	20.7	24.2	31.3
4	Oncology	4.4	5.2	6.7	7.6	6.7

5	Neurosciences	5.4	6.2	8.7	9.4	8.9
6	Chemistry Physical	9.1	11.5	16.8	18.5	21.6
7	Surgery	2.7	3.1	3.9	4.2	4.0
8	Physics Applied	10.5	14.1	23.4	27.1	39.1
9	Pharmacology Pharmacy	4.7	5.4	6.8	7.2	7.7
10	Clinical Neurology	3.9	4.5	5.5	6.2	7.6
11	Engineering Electrical Electronic	11.3	15.7	22.8	25.7	23.0
12	Cell Biology	4.2	4.7	5.8	6.1	8.5
13	Medicine General Internal	2.8	2.7	2.0	1.7	1.1
14	Cardiac Cardiovascular Systems	4.6	5.2	6.9	8.7	8.9
15	Immunology	4.2	4.7	6.5	7.5	9.7
16	Multidisciplinary Sciences	6.7	8.4	13.8	16.1	21.5
17	Environmental Sciences	7.4	8.8	12.6	14.6	20.2
18	Physics Condensed Matter	10.2	13.3	19.8	23.0	32.0
19	Endocrinology Metabolism	5.1	5.6	7.4	7.1	6.0
20	Gastroenterology Hepatology	4.6	5.2	6.6	7.6	11.3
21	Engineering Chemical	12.9	17.6	30.9	34.7	43.2
22	Biotechnology Applied Microbiology	5.1	5.6	4.8	4.7	0.8
23	Hematology	5.3	6.1	8.0	10.2	12.1
24	Radiology Nuclear Medicine	3.5	4.2	5.7	5.5	4.3
25	Genetics Heredity	5.8	6.3	6.0	5.8	3.0
26	Psychiatry	4.5	5.3	7.1	7.7	6.9
27	Physics Multidisciplinary	8.8	11.6	19.6	22.4	27.7
28	Peripheral Vascular Disease	5.0	5.6	7.4	8.6	10.3
29	Medicine Research Experimental	2.1	2.1	2.2	2.6	4.1
30	Public Environmental Occupational Health	5.5	6.2	7.5	7.5	7.1
31	Plant Sciences	7.8	9.2	12.1	12.9	14.9
32	Optics	11.4	16.4	33.4	39.7	47.6
33	Mathematics	7.9	11.4	17.9	27.1	45.0
34	Chemistry Organic	8.3	10.8	16.6	18.3	24.3
35	Microbiology	6.4	7.3	9.0	9.0	7.8
	Average	6.5	8.0	11.6	13.2	15.8

overrepresentation. “Engineering Electrical Electronic” has 5.3% of reviews in the 1% most cited papers and 10.7% in the 0.1% most cited papers but the overrepresentation values are as high as 11.3 and 22.8, respectively. Similarly, “Mathematics” have 1.1% reviews in the 1% most cited papers and 2.5% in the 0.1% most cited, but overrepresentation values of 7.9 and 17.9 for 1% and 0.1% most cited papers, respectively. In these areas, the production of reviews is rather limited (0.39% in “Engineering Electrical Electronic” and 0.10% in “Mathematics”), however, they are very well cited. Again it seems that the reviews produced in the areas with the highest shares of reviews in total publications are less well cited than those produced in areas with lower share of reviews in total publications (see Fig. S3, Supplementary information).

3.6. Uncitedness rate evolution with time

The percentage of uncited reviews is also considerably lower than for other document types. Fig. 8 shows the percentage of uncited reviews and uncited original research articles as well as the ratio uncited articles/uncited reviews evolution with time. As observed, the uncitedness rate of reviews is around 5%, on average, while the uncitedness for regular articles is 10%. As the uncitedness was evaluated at mid 2016, the uncitedness increased exponentially at the latest publication years, and was especially high in 2014 and 2015. The ratio between uncitedness of articles and reviews varied from around 2.3–2.5 for the papers published in 2000–2006 period to 2.1–2.2 for the papers published in 2007–2014. Then, a sharp decrease to 1.6 occurred in 2015. This sharp decrease in uncitedness ratio can be also explained by the fact the largest differences in citations received between reviews and articles, such as uncitedness rate, occurs at longer periods of time between the publication year considered and the time of citations counting.

The results obtained are in agreement with previous studies. Haustein (2012), for example, analyzed the uncitedness in 2010 of different document types published in 45 journals between 2004 and 2008 (168,109 total publications), i.e. after 2–6 years after publication. The proportion of uncited documents was found to be 4.0% for review papers (the lowest value among the different document types analyzed) and 12.9% for articles. Similar results were obtained by Zhao (2015), focused on review papers published in the period 2005–2014 covered by SCI (60,655 documents). The average uncitedness ratio in ten years was 9.9%, however, the ratio of uncitedness decreased rapidly in the following three years after publication, and subsequently stabilized at around 4% in 5–10 years.

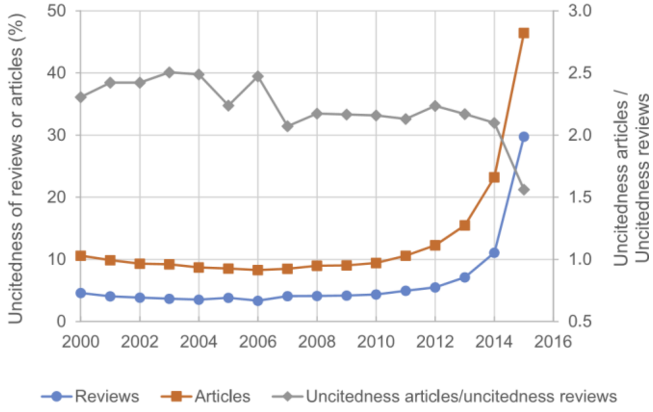

Fig. 8. Uncitedness of reviews and articles and ratio uncitedness of articles/uncitedness of reviews for SCI-E papers published between 2000 and 2015. Uncitedness was evaluated at July-August 2016.

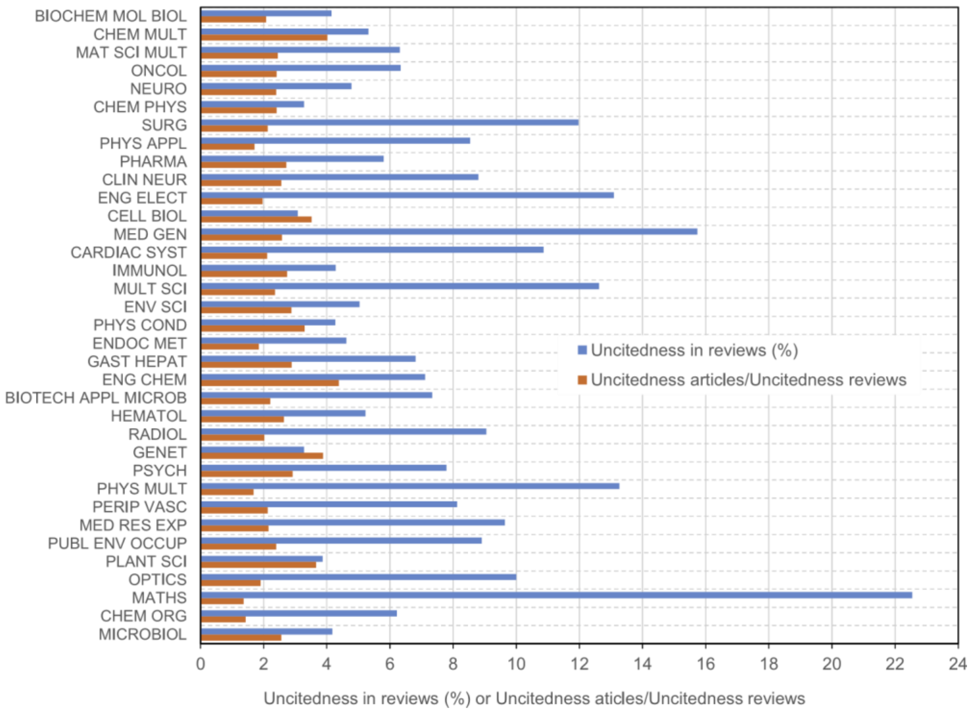

Fig. 9. Uncitedness rate of reviews and ratio uncitedness reviews/uncitedness articles for articles published in 2000–2015 in SCI-E by subject categories.

3.7. Uncitedness rate by research areas

Fig. 9 shows the percentage of uncited reviews and the ratio uncitedness articles/uncitedness reviews by research areas. The percentage of uncited reviews varied from 3.1% to 22.5%, depending on the area, the average being 7.8% and the median 6.8%, while the rate of uncited articles, varied between 7.9% and 40.6% with an 18.2% average and 16.2% median. On the other hand, the ratio uncitedness of articles/uncitedness of reviews varied from 1.37 to 4.38, being 2.5 the average and 2.4 the median.

The greatest uncitedness rates in reviews (>10%) were observed in "Surgery", "Engineering Electronical Electronic", "Medicine General Internal", "Cardiac Cardiovascular Systems", "Multidisciplinary Sciences", "Physics Multidisciplinary" and "Mathematics". In some cases, the high uncitedness rate is correlated with the highest share of reviews in total publications. However, it is very interesting to notice that "Mathematics" is the research area with the greatest rate of uncitedness (22.5%) and "Engineering Electronical Electronic" one of the greatest (13.1%). These areas were previously identified as those with very low share of reviews in total publications. The lowest uncitedness ratio, i.e. <5%, occurred in "Biochemistry Molecular Biology", "Chemistry Physical", "Cell Biology", "Immunology", "Physics Condensed Matter", "Endocrinology Metabolism", "Genetics Heredity", "Plant Sciences" and "Microbiology". Again the correlation is not as clear as in other citation parameters

5 Summary of overcitation, overrepresentation in most cited papers and uncitedness in review papers.

	%R	AC-R/AC-A	Reviews 1%mostcited(%)	Overrep.1%most cited	Uncited. Articles/Uncited. reviews
BiochemistryMolecularBiology	7.52	1.97	28.4	5.0	2.08
ChemistryMultidisciplinary**	3.33	4.92	34.2	12.4	4.02
MaterialsScienceMultidisciplinary**	1.49	6.47	15.2	11.8	2.45
Oncology*	5.72	1.61	25.3	5.4	2.41
Neurosciences	6.10	2.40	32.7	6.7	2.40
ChemistryPhysical**	1.79	4.24	16.2	11.7	2.41
Surgery	3.61	1.41	9.9	3.3	2.13
PhysicsApplied**	1.24	6.4	13.0	12.7	1.71
PharmacologyPharmacy*	10.89	2.18	51.2	5.8	2.72
ClinicalNeurology*	5.40	1.58	21.3	4.8	2.56
EngineeringElectricalElectronic**	0.47	6.74	5.3	13.7	1.97
CellBiology	7.71	2.03	32.1	5.5	3.52
MedicineGeneralInternal*	6.54	1.34	18.3	3.4	2.58
CardiacCardiovascularSystems*	3.60	1.77	16.4	5.5	2.11
Immunology*	7.37	2.09	31.3	5.3	2.74
MultidisciplinarySciences	1.65	2.55	11.1	8.2	2.36
EnvironmentalSciences	3.02	2.86	22.4	8.9	2.88
PhysicsCondensedMatter**	1.38	6.00	14.1	12.9	3.30
EndocrinologyMetabolism	5.74	2.68	29.5	6.4	1.85
GastroenterologyHepatology*	3.87	1.56	17.8	5.7	2.89
EngineeringChemical**	1.39	4.70	17.9	15.1	4.38
BiotechnologyAppliedMicrobiology	5.91	2.68	30.1	6.2	2.21
Hematology*	3.92	1.74	20.6	6.7	2.64
RadiologyNuclearMedicine*	3.10	1.36	10.7	4.2	2.02
GeneticsHeredity	5.61	2.61	32.3	7.6	3.88
Psychiatry*	4.96	1.60	22.4	5.2	2.92
PhysicsMultidisciplinary**	1.96	4.74	17.2	12.0	1.68
PeripheralVascularDisease	3.42	1.76	17.0	6.3	2.13
MedicineResearchExperimental*	7.13	1.59	15.3	2.5	2.16
PublicEnviron.OccupationalHealth*	3.31	2.23	18.1	5.6	2.40
PlantSciences	4.92	3.69	38.2	9.9	3.66
Optics**	0.70	4.12	8.0	13.6	1.91
Mathematics	0.14	2.07	1.1	11.1	1.37
ChemistryOrganic	3.34	2.81	27.7	10.8	1.43
Microbiology	6.60	2.68	42.1	8.3	2.56

withtheactualshareofreviews,i.e.someoftheresearchareaswiththelowestuncitednessratioarethosewiththehighest shareofreviewsintotalpublications, i.e. “Biochemistry Molecular Biology” (5.4%), “Cell Biology”, (5.8%), “Immunology” (5.9%) or “Microbiology” (5.0%) (see Fig. S4, Supplementary information).

Similar results were obtained analyzing the uncitedness of articles/uncitedness of reviews. Some of the areas with the highest values (>3) are the following: “Chemistry Multidisciplinary”, “Cell Biology”, “Physics Condensed Matter”, “Engineering Chemical”, “Genetics Heredity” and “Plant Sciences”(average3.8).Ontheotherhand,theuncitednessofreviews andarticleswasmoresimilar(uncitednessofarticles/uncitednessofreviews<2)inthe following areas: “Physics Applied”, “Engineering Electrical Electronic”, “Endocrinology Metabolism”, “Physics Multidisciplinary”, “Optics”, “Mathematics”and “ChemistryOrganic”(average1.7).

3.8.Summary:comparisonamongresearchareas

Table 5 showsasummaryindicatingtheimportanceofovercitation,overrepresentationinthemostcitedpapersand uncitednessrateofreviewpapers comparedtoregulararticles.Formostresearchareasthereisastrongcorrelationbetween thevaluesofAC-R/AC-Aandtheoverrepresentationinthemost citedpapersresearch,but,thereisaminorcorrelationwith uncitednessratio.

Thenineresearchareasinwhichtheeffectofreviewsoncitationsismoreimportantisindicatedbytwoasterisks(**), theaverageshareofreviewsintotal publicationis1.5%.Ontheotherhand,thetwelveresearchareasinwhichtheeffectof reviewsislessimportantaremarkedwithoneasterisk(*),theyhavean average5.5%shareofreviews.Theotherfourteen areastheeffectofreviewsincitationratesisintermediate.

3.9.Effectofreviewpapersonindividualmetrics

Finally,asimplifiedanalysisonhowthecitationmetricsofanindividualcanbeaffectedbytheshareofreviewpapersinhis publicationsispresented.It wasassumedthattheauthoronlypublishedtwodocumenttypes:reviewsandoriginalresearch

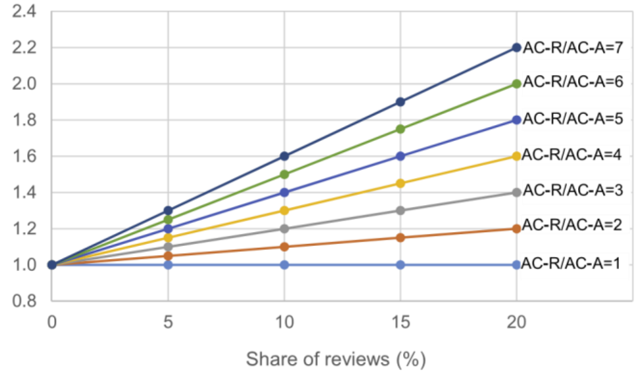

Fig. 10. Ratio between average citations of an individual publishing R% of reviews and other publishing 0% reviews vs. share of reviews at different AC-R/AC-A ratio.

articles. Total publications is TP and the share of reviews and articles in total publications are R. and (100-R), respectively. Furthermore, the citations received by both documents was established from AC-R/AC-A ratio: AC-A for articles and (ACA)·[(AC-R)/(AC-A)] for reviews. From these assumptions and definitions, the total citations received by the individual (TC) is given by Eq. (1).

$$TC = TP \cdot \frac{(100 - R)}{100} \cdot (AC - A) + \frac{TP \cdot R}{100} \cdot \left(\frac{AC - R}{AC - A}\right) \cdot (AC - A)$$

Obviously, TC of the individual will be greatest for the highest TP, R, AC-A and (AC-A/AC-A) ratio. Furthermore, average citations per document (AC) of an individual can be calculated by Eq. (2), where AC only depends on R, AC-A and the ratio AC-R/AC-A:

$$AC = \frac{(100 - R)}{100} \cdot (AC - A) + \frac{R}{100} \cdot \left(\frac{AC - R}{AC - A}\right) \cdot (AC - A)$$

Next, it can be calculated the ratio between the average citations of an individual publishing a R percentage of reviews (AC_R) and the average citations of an individual with R=0% (AC_0). This ratio only depends on the ratio (AC-R/AC-A) and the share of reviews (R) (Eq. (3)):

$$\frac{AC_R}{AC_0} = \frac{R}{100} \cdot \left(\frac{AC - R}{AC - A}\right) + \frac{(100 - R)}{100}$$

In such way, the effect of a certain share of reviews in the publications of an individual could be compared with the base case (no reviews published) for different AC-R/AC-A ratios (Fig. 10).

As determined previously, the average AC-R/AC-A ratio for the 35 largest SCI-E subject categories was 3. At these conditions, the average citations per document of an individual publishing 20% of reviews, for example, would be 40% greater than individual not publishing reviews. However, the AC-R/AC-A ratio varied from 1.34 to 6.47 in the research hareas analyzed. For AC-R/AC-A=5, for example, a 20% of reviews would mean 80% greater average citations per document for this individual; and this is the case for many research areas such as "Chemistry Multidiscplinary". "Physics Applied", "Materials Science Multidisciplinary", "Engineering Chemical", "Physics Condensed Matter", "Physics Multidisciplinary", "Optics", "Endocrinology Metabolism", "Chemistry Physical" and "Plant Sciences". Obviously, h-index would be also largely affected by the share of reviews.

Finally, an example showing the effect of reviews in the citations received by several colleagues from the Faculty of Chemistry of the Complutense University of Madrid, is shown in Table 6. As observed from outputs from real researchers with share of reviews between 3.9% and 11.2% and AC-R/AC-A from 2.7 to 5.4, exclusion of reviews from citation counts meant: 15–36% decrease of total cites, 10–28% decrease of average citation per document and a reduction of h-index from 0 to 21%. According to these data, one could expect an individual publishing 20% of reasonable cited reviews, total cites and average citations per document would be around 60–70% greater, and the h-index around 40% greater, compared to an individual not publishing any review.

4. Conclusions

The citation rate of an article is influenced by many factors, one of those being the document type. Review papers are overcited and overrepresented in the most cited papers of a research area compared to original research articles. Although that occurs for all research areas, important differences among them have been observed.

The overcitation and overrepresentation in the most cited papers was more relevant in the areas with the lowest share of reviews in total publications. Some of these areas are: “Chemistry Multidisciplinary”, “Materials Science Multidisciplinary”, “Chemistry Physical”, “Physics Applied”, “Engineering Electrical Electronic”, “Physics Condensed Matter”,

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Comparison of the main citation rates for different researchers from Faculty of Chemistry (Complutense University of Madrid), both including and excluding review papers.

	TP	Reviews	AC-R/AC-A	Citation statistics for total publications			Citation statistics excluding reviews		
				TC	AC	h	TC	AC	h
#1	576	44(7.6%)	2.68	23,308	40.47	71	19,082 (↓18.1%)	35.87 (↓11.4%)	63 (↓12.7%)
#2	525	31(5.9%)	5.20	19,061	36.31	67	14,330 (↓24.8%)	29.01 (↓20.1%)	59 (↓13.6%)
#3	419	47(11.2%)	4.41	8,069	19.2624,73	43	5,133 (↓36.4%)	13.80 (↓28.3%)	34 (↓20.9%)
#4	332	13(3.9%)	4.23	8,210	14.93	44	6,977 (↓15.0%)	22.43 (↓9.3%)	44 (=)
#5	86	4(4.6%)	5.41	1,284	11.73	19	1,016 (↓20.9%)	12.39 (↓17.0%)	19 (=)
#6	52	3(5.8%)	2.90	610	19.93	14	518 (↓15.1%)	10.57 (↓9.9%)	13(=)
#7	29	2(6.9%)	2.86	578		13	477 (↓17.5%)	17.67 (↓11.8%)	11 (↓18.2%)

TP = total publications; TC = total cites (with self-citations); AC = average citation per document.

“Engineering Chemical”, “Physics Multidisciplinary” and “Optics”. In these areas, review papers are cited, on average, 5.4 times more than original research articles. Furthermore, the average share of reviews in the 1% and 0.1% most cited papers in these areas is 15.7% and 27.9%, respectively, while reviews only represented 1.24% of total publications in these areas. In other words, review papers are 12.7 and 22.5 times overrepresented in the 1% and 0.1% most cited papers, respectively, compared to their share in total publications. In addition, the uncitedness rate for reviews in these areas was 2.65 times lower than for regular articles.

It has also been observed that the overcitation and overrepresentation of review papers is significantly lower in areas in which the share of papers in total publications is already high. It seems there is some saturation in the number of reviews which make them being less well cited than in other research areas.

It has been demonstrated than the share of reviews for an individual can greatly impact their citation output such as total cites, average citations or h-index. As the share of reviews in total publications have continuously increased in the last 25 years and this trend has not slowed down, it is suggested to exclude review papers from total citations of individuals. The aim is trying not giving the bad massage for individuals that is better to produce reviews than original papers, especially for younger researchers looking for a position in R&D.

Authors contributions

Ruben Miranda: Concieved and designed the analysis; Collected the data; Contributed data or analysis tools; Performed the analysis; Wrote the paper.

Esther Garcia-Carpintero: Concieved and designed the analysis; Collected the data; Contributed data or analysis tools; Performed the analysis; Wrote the paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.joi.2018.08.006.

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