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H-Classics: characterizing the concept of citation classics through H-index

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Abstract Citation classics identify those highly cited papers which are an important reference point in a research field. To identify a paper as a citation classic we have to fix a citation threshold value. Usually, this threshold value should not be the same for all research fields because each field presents its respective citation pattern. Studies of citation classics in the literature define particular criteria and methods to set citation thresholds, which are often set arbitrarily and designed ad-hoc, and do not allow the scientific community to validate and compare their results. In this paper we introduce the concept of H-Classics to overcome this problem and provide scientific community a standardization of key constructs. We present a new and systematic method to identify citation classics. This identification method of highly cited papers is based on the H-index and thank to the properties of H-index it is sensitive to the own characteristics of any research discipline and also its evolution. Therefore, the concept of H-Classics allows to systematize search procedure of citation classics for any field of research.

Keywords H-index · Citation classics · Bibliometric measures

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Introduction

Bibliometrics is a science based on the citation analysis of the papers and used mainly to evaluate research performance (Moed 2009). A basic assumption of citation analysis is that the more often a paper becomes cited the greater its influence on the field (Garfield 1979). Bibliometrics uses the citation analysis to develop evaluation metrics that allow to quantify the impact of a journal or an individual or a paper. Some examples of citation based metrics are Journal Impact Factor (Garfield 1979), H-index (Hirsch 2005), Citation Classics (Garfield 1977), respectively.

Citation classics is a bibliometric concept introduced by Garfield (1977) to designate those highly cited papers of a scientific discipline. Citation classics help to discover potentially important information for the development of a discipline and understand the past, present and future of its scientific structure. By this reason, for some authors the citation classics are considered as the *"gold bullion of science"* (Smith 2007; Stack 2012). For example, an analysis of the citation classics of a research field

- allows for the recognition of major advances in the discipline, i.e., to identify emergent or basis or hot or superstar topics in order to inspire other works on the area (Garfield 1977; Tam et al. 2013);
- gives a historical perspective on the scientific progress of the speciality (Smith 2007; Stack 2012); and
- identifies also the main intellectual markers of the research field, which could be journals or researchers or countries or research groups or institutions (Baltussen and Kindler 2004; Garfield 1977; Smith 2007; Stack 2012; Tam et al. 2013).

The citation classic concept is well understood by the scientific community, however there is still no standard way to identify them. There are two approaches to identify citation classics: (i) setting citation thresholds (Gehanno et al. 2007; Ibrahim et al. 2012; Ponce and Lozano 2010, 2011; Rosenberg et al. 2010) and (ii) choosing a number of papers in the top of the list of highly cited papers (Cassar et al. 2012; Feijoo et al. 2013; Garfield 1977; Stack 2012, 2013; Tam et al. 2012). Former is related to the definition of citation thresholds or rates of a discipline that have to meet a paper to be considered a citation classic of that discipline. For example, following Garfield's (2013) recommendations some authors use 400 cites received as citation rate (Ibrahim et al. 2012; Ponce and Lozano 2010, 2011) and others 100 (Gehanno et al. 2007), but without any rigorous scientific argument. And the problem is that citation rates differ for each discipline (Garfield 2013). Furthermore, in the current information society with the increasing use of the Internet the possibilities of dissemination of information is growing and the number of citations received well. Therefore, it makes no sense to set strict thresholds, but rather variable thresholds and adaptable to the particular evolution of each research area. On the other hand, latter is to choose a number of papers from the list of papers sorted by citations. Some authors set a specific number of publications as the ideal number of citation classics (e.g. 100, 50 or 25 are values used) (Cassar et al. 2012; Feijoo et al. 2013; Garfield 1977; Tam et al. 2012) and others set a percentage of papers sorted by citations received (the top 1 % or top 0.1 % are used) (Garfield 1987; Levitt and Thelwall 2009; Stack 2012, 2013). Again, the problem is that there is no serious scientific argument that supports those decisions. Thus, both identification procedures of citation classics lack any scientific support, are made ad-hoc and can bias the choice of the classics.

To overcome those problems, in this paper we introduce the concept of H-Classics. H-Classics are defined as citation classics identified through the H-index defined by Hirsch

(2005). It is well known the value of the H-index to evaluate the scientific quality of a researcher and also it has been successfully applied to evaluate the quality of journals (Braun et al. 2006), institutions (Prathap 2006) and even countries (Jacsó 2009). We propose its application to identify the citation classics of a research area. So, we present a new and systematic methodology to characterize the citation classics and, in such a way, we provide scientific community a standardization of key constructs to identify classics. Thank to the H-index this new methodology is adaptable to the own citation practices of any research discipline and also its evolution. Thus, the concept of H-Classics is an unbiased and fair criterion to systematize search procedure of citation classics for any field of research.

To do so, the paper is set out as follows. "Preliminaries: citation classics and the H-index" section presents the preliminaries, by analyzing the concept of citation classics and introducing the H-index. In "H-Classics: a new concept for analyzing the literature classics" section, we present the concept of H-Classics and the new methodology to identify citation classics. "Cases of study based on the H-Classics" section presents some practical examples of H-Classics in various research areas and some of its benefits are shown. Finally, some concluding remarks are pointed out in "Concluding remarks" section.

Preliminaries: citation classics and the H-index

In this section we present the concept of citation classics and also analyze its problematic. On the other hand, we present the popular bibliometric measure H-index, which is used to characterize the concept of H-Classics in "H-Classics: a new concept for analyzing the literature classics" section.

Citation classics

Garfield (1977) initially defined the concept of citation classics to identify those most frequently cited papers that set the tone for development of a discipline. Then, he and his research team developed the project "Citation Classics Commentaries" to capture more of the human side of science. These citation classics commentaries were published in the periodical publication *Current Contents*. Each citation classic commentary is a two-page essay written by the citation classic author who provided personal information on how the work was developed (basic ideas, obstacles encountered, highlights) (Garfield 2013). The project was discontinued in 1993, but it has laid the foundation for the development of other bibliometric products marketed by Thomson Reuters, as for example, the *Hot Papers* (see http://sciencewath.com) or *The List of Highly Cited Papers or Researchers* (see http://www.highlycited.com/).

Garfield subsequently proposed other definitions of citation classics as "*A citation classic is a work whose citation count placed it in the top 1 % of works*" (Garfield 2013) or "*A citation classic is a highly cited publication as identified by the Science Citation Index(SCI) the Social Sciences Citation Index SSCI), or the Arts & Humanities Citation Index (A & HCI)* (Garfield 2013)". And, the study of the citation classics of a research area has aroused much interest in the scientific community because it helps researchers to understand the scientific structure of a discipline, its evolution and also to discover new knowledge useful for its future scientific progress, including:

- The discovering of research topics of special interest within the scientific community: basic themes, trend or hot themes, emergent themes, etc.
- The identification of highly relevant authors/institutions/groups in the research area.

Some research fields which have recently published analysis on citation classics are: "Social Work" (Hodge et al. 2012), "Integrative & Complementary Medicine" (Tam et al. 2012), "Neurosurgery" (Ponce and Lozano 2010), "Parkinson" (Ponce and Lozano 2011), "Critical Care Medicine" (Rosenberg et al. 2010), "Suicidology" (Stack 2012), "Deviant Behavior" (Stack 2013), "Information & Library Science" (Levitt and Thelwall 2009), "Occupational Medicine" (Gehanno et al. 2007), "Epilepsy" (Ibrahim et al. 2012), "Pain Medicine" (Li et al. 2012), "Plastic and Reconstructive Surgery" (Zhang et al. 2012), "Pancreatology" (Cao et al. 2012), "Endodontology" (Fardi et al. 2011), "Dentistry" (Feijoo et al. 2013), "Respirology" (Tam et al. 2013), "Orthodontist" (Hui et al. 2013), "Orthopedics" (Namdari et al. 2012), "Arthroscopy" (Cassar et al. 2012), "Vascular Surgery" (O'Connor et al. 2011), etc,. An overview of some key features and findings of these analysis are presented in Table 1.

As aforementioned, there are two kinds of identification procedures of citation classics:

1. The first one involves the establishing citation rates or thresholds to be met by the published papers. Following the Garfield's recommendations (Garfield 2013), a publication cited more than 400 times should be considered a classic (Ibrahim et al. 2012; Ponce and Lozano 2010, 2011); but in some fields with fewer researchers, 100 citations might qualify a work (Gehanno et al. 2007; Rosenberg et al. 2010). The problem is that citation rates differ for each discipline (Garfield 2013) given that the citation counts of a scientific field depends on many factors (Albarrán et al. 2011; Bornmann and Daniel 2008): aging of the area, citation distribution, publication and citation practices, the activity rate of the scientific community, the number of scientists, channels of information dissemination, etc. Therefore, if for some fields can be set as citation rate to be considered a citation classic have received 400 citations, for others that score of citations is impossible to be reached for some paper. But furthermore, there is one open question more: why do authors establish 400 citations and not 350 or 399?. Would it be possible to give a common selection guidelines?.
2. The second one involves the choosing a specific number of papers placed in the top of the list of highly cited works. Garfield points out two methods to do it: (i) to set a concrete number of papers (Garfield 1977) or (ii) to set a percentage of papers (top 1 % of highly cited works is a usual percentage) (Garfield 1987). Examples of specific numbers of papers used to study the classics are 100 most highly cited articles (Cao et al. 2012; Fardi et al. 2011; Feijoo et al. 2013; Hodge et al. 2012; Hui et al. 2013; Li et al. 2012; O'Connor et al. 2011; Zhang et al. 2012) or 50 most highly cited articles (Namdari et al. 2012; Tam et al. 2012, 2013) or 25 most highly cited articles (Cassar et al. 2012). On the other hand, some usual percentages used are top 1 % of highly cited works (Stack 2012, 2013) or top 0.1 % (Levitt and Thelwall 2009). Again we find some questions:

- Maybe 100 could be a representative number of citation classics in some research areas (e.g Social Work), but if we have a large research area as Physics, we would need 2000 or more citation classics to represent the classical literature.
- Why would we have to use 100 or 50 or 25 and not 95 or 45 or 35, respectively? or why would we have to use the top 1 % and not the top 2 % or the top 0.5 %?.

Table 1 Data of studies on citation classics

Discipline	References	Citation rate	#(Classics)
Epilepsy	Ibrahim et al. (2012)	400	89
Neurosurgery	Ponce and Lozano (2010)	400	106
Parkinson	Ponce and Lozano (2011)	400	107
Critical Care Med.	Rosenberg et al. (2010)	100	1187
Occupational Med.	Gehanno et al. (2007)	100	85
Suicidology	Stack (2013)	96	12
Deviant Behav.	Stack (2012)	43	10
Inf. & Lib. Sci.	Levitt and Thelwall (2009)	118	82
Soc. Work	Hodge et al. (2012)	41	100
Pain Med.	Li et al. (2012)	302	100
Plastic and Rec. Surg.	Zhang et al. (2012)	165	100
Vascular Surgery	O'Connor et al. (2011)	194	100
Pancreatology	Cao et al. (2012)	163	100
Endodontology	Fardi et al. (2011)	87	100
Dentistry	Feijoo et al. (2013)	326	100
Orthodontist	Hui et al. (2013)	89	100
Integ. & Comp. Med.	Tam et al. (2012)	52	50
Respirology	Tam et al. (2013)	615	50
Orthopedics	Namdari et al. (2012)	192	50
Arthroscopy	Cassar et al. (2012)	189	25

Therefore, in both approaches we find the same problematic. The identification parameters of citation classics are set according to the traditional recommendations, without considering a precise scientific argument and neither the circumstances of the research area when the study is done. Consequently, this could introduce a bias in the choice of the citation classics. Therefore, it would be desirable to find some transparent scientific criterion to support the setting of citation rates and that such criterion could reflect the evolving of the research area too.

H-index

H-index is one of the most popular bibliometrics indicators which was originally introduced by Hirsch (2005) to measure the scientific performance of a researcher through his/her publications. The original definition was:

> A scientist has index h if h of his or her N_p papers have at least h citations each, and the other $(N_p - h)$ papers have $\leq h$ citations each.

Burrell (2007) points out that the *H*-index identifies the most productive core of an author's output in terms of the most cited papers. For this core, consisting of the first h papers, Rousseau (2006) introduced the term *Hirsch core* (*H*-core), which can be considered as a group of high-performance publications with respect to the scientist's career (Jin et al. 2007).

Due to its numerous advantages the H-index has been well received by the scientific community and many research papers on H-index have been developed (for more

information to read the review by Alonso et al. (2009)). Its main advantage is that H-index comprises in a single indicator a measure of quantity and impact of the scientific output of a researcher, aspects that traditionally have been measured separately by using different indicators. Another benefit of this indicator is that it is quite simple to compute from the citation data available through the scientific databases as Web of Knowledge and Scopus. The H-index has been proven to be robust in the sense that it is insensitive to a set of lowly cited papers (Vanclay 2007). Additionally, increasing the *H*-index is difficult as each unit increment implies receiving citations in a larger number of papers. Moreover, the *H*-index is insensitive to one or several outstandingly highly cited papers (which is usually considered as a drawback). H-index is an indicator of the scientific life of a researcher, i.e., H-index is sensitive to the evolution of the scientific career of a researcher, so that it reflects the evolution of his/her publications and citations.

In order to take advantage of the H-index some authors have extended its application to characterize the scientific activity of other entities, as for example, to measure the impact of journals (Braun et al. 2006), the scientific performance of institutions (Prathap 2006) and even the scholarly productivity of countries (Jacsó 2009). In the following section, we study its application to characterize the concept of citation classics of a research area, providing a robust and transparent method to develop studies of literature classics.

H-Classics: a new concept for analyzing the literature classics

In this section, we present the concept of H-Classics as a new tool useful to identify and analyze citation classics of a research area. H-Classics is based on the H-index, and therefore, it provides a rigorous and scientific method to discover the most highly cited papers in a scientific discipline. It is introduced to avoid potential biases that appear in many studies of citation classics that have been made so far.

Suppose that we have retrieved *N* articles and their respective citations subject scientific category of *A*. As we calculate the H-index of a researcher, we could also calculate the H-index of category *A*. Then,

> a paper P of scientific category A is considered a H-Classic of A if and only if P is inside of the H-core of A.

In such a way,

> H-Classics of a research area A could be defined as the H-core of A that is composed of the H highly cited papers with more than H citations received.

Then, the identification process of citation classics of a research area through the concept of H-Classics could be carried out in the following steps:

1. *Choosing the bibliographic database to locate the scientific production and citations*. Three potential databases are known, Google Scholar, Scopus and Web of Science (WoS), latter being the most widely used database that collects as much information more reliably and with more analysis tools to process information.
2. *Set the research area under study*. To do this, citation classics studies focus on analyzing papers published in journals, and furthermore by using two types of papers, "article" and "review". Therefore, the group of journals that are traditionally used to disseminate scientific advances made in the area should be identified, and then, their publications and citations received from the bibliographic database should be

retrieved. In the case of WoS, if we're lucky and the area to analyze matches any of the scientific areas of the Journal Citation Report (JCR), then making a simple search in WoS it is possible to get all the information necessary to characterize the area. If it is difficult to identify the area by means of both a set of magazines or an area of the JCR, then we should define an appropriate query to find all related papers and their respective citations. In any case, an appropriate query to collect our interests should be defined. In Table 2, there are several examples of queries to characterize different disciplines working with WoS, i.e., "Suicidology" (Stack 2012), "Epilepsy" (Ibrahim et al. 2012), and "Dentistry" (Feijoo et al. 2013).

3. *Compute the H-index of the research area*. The computation of H-index of research area is done by establishing a ranking of the papers according to their citations. If WoS is used to retrieve the scientific production, WoS provides us filtering tools to compute easily the H-index of the research area. For example, in Table 3 we show any results to compute the H-Index in several JCR research areas according to the data stored in the WoS (Computation on June 22 2013): "Social Work", "Family Studies", "Transplantation", "Dentistry", "Computer Science", "Mathematics" and "Physics". We also show some key features and findings like the citation rate (*Cr*) or the number of citations received by the last paper included in the H-core, and the number of papers published in the research area (#(*Papers*)) in the Timespan (1900–2013) and by considering only "Articles" and "Reviews".
4. *Compute the H-core of the research area*. This step consists in recovering the H highly cited papers that are included in the H-core of the research area. It is clear that H-core of the research area identifies its H-Classics, and thus, H-index of a research area represents the cardinality of the H-core of the area, i.e., H-index = #(H-Classics). Again, we should point out that using WoS this operation is facilitated.

Table 2 Queries to set research areas in WoS

Discipline	Query type	Query
Suicidology	Journal	SO = (Suicide and Life Threatening Behavior)
Epilepsy	Topic	TS = (epilepsy or epilepsies or epileptic or epilepticus or seizures or seizure),
Dentistry	JCR area	SU = (Dentistry, Oral Surgery & Medicine)

Table 3 Computing H-index of JCR areas

Discipline	Cr	H-index	#(Papers)
Social work	126	125	46402
Family studies	168	168	46117
Transplantation	224	224	116623
Dentistry	246	246	184646
Computer science	624	624	824198
Mathematics	642	640	1104332
Physics	1171	1171	3256681

Some advantages of H-Classics to characterize the more influential papers of a research category are the following:

- H-Classics of a scientific field is the result of the combination of both measures, the number of papers published in the field and the impact of those publications. Therefore, H-Classics comprises in a single procedure both approaches existing in the literature to identify citation classics. In such a way, it provides a more complete view of the highly cited scientific production of a research area.
- As aforementioned, many of the citation classics studies presented so far are based on arbitrary criteria and they could be skewed and even incomplete. H-Classics is based on the H-index and therefore, it provides a scientific, robust and transparent criterion to identify citation classics of the scientific literature. In such a way, we provide scientific community a precise indicator to develop and justify any future studies of citation classics to be done.
- H-Classics is very simple to compute once the list of papers and their respective citations are retrieved. If the production and citation data of research area are available through a popular scientific databases as WoS, the identification of the H-Classics is very easy: Firstly, we compute the H-index of the area and then we retrieve the papers included in its H-core.
- H-Classics is a criterion sensitive to the dimension of the research area. So, in Table 3 those large research areas (as "Computer Science", "Mathematics" or "Physics") present a higher number of citation classics (*H-index*) than those small ones (as "Social Work", "Family Studies", "Transplantation", and "Dentistry").
- H-Classics is also a criterion sensitive to the citation pattern of each research area. For example, in Table 3 if we compare two research areas with similar dimensions as "Social Work" (46.402 papers published) and "Family Studies" (46.117 papers published), H-Classics returns very different quantities of citation classics, 125 and 168, respectively. Therefore, H-Classics is able to detect differences in their respective impacts or citations. In this case, "Family Studies" attracts more citations than "Social Work". This can be contrasted in Fig. 1, where we compare both categories in the period (2005–2010) and we see that although both have similar amounts of publications, however the scientific category of "Family Studies" receives many more citations in each year.

Cases of study based on the H-Classics

In this section, we analyze the behavior of the H-Classics and show its benefits in comparison with some studies of citation classics presented in Table 1, which were developed with traditional tools. We should point out that in this section, the term *T-Classics* represents the citation classics of a research area which were identified using a traditional approach. Therefore, T-Classics could be established by setting citation thresholds or choosing a number of papers in the top of the list of highly cited papers. Specifically, we focus on those studies of citation classics that were developed using WoS and a timespan next to the year 2013, i.e., (1900–2010), (1900–2011), and (1900–2012). We do this so that the citations received up to 2013 affect as little as possible the process of identification of the H-Classics.

In particular, we apply H-Classics to identify the citation classics in the following cases: "Epilepsy" (Ibrahim et al. 2012), "Parkinson" (Ponce and Lozano 2011), "Suicidology"

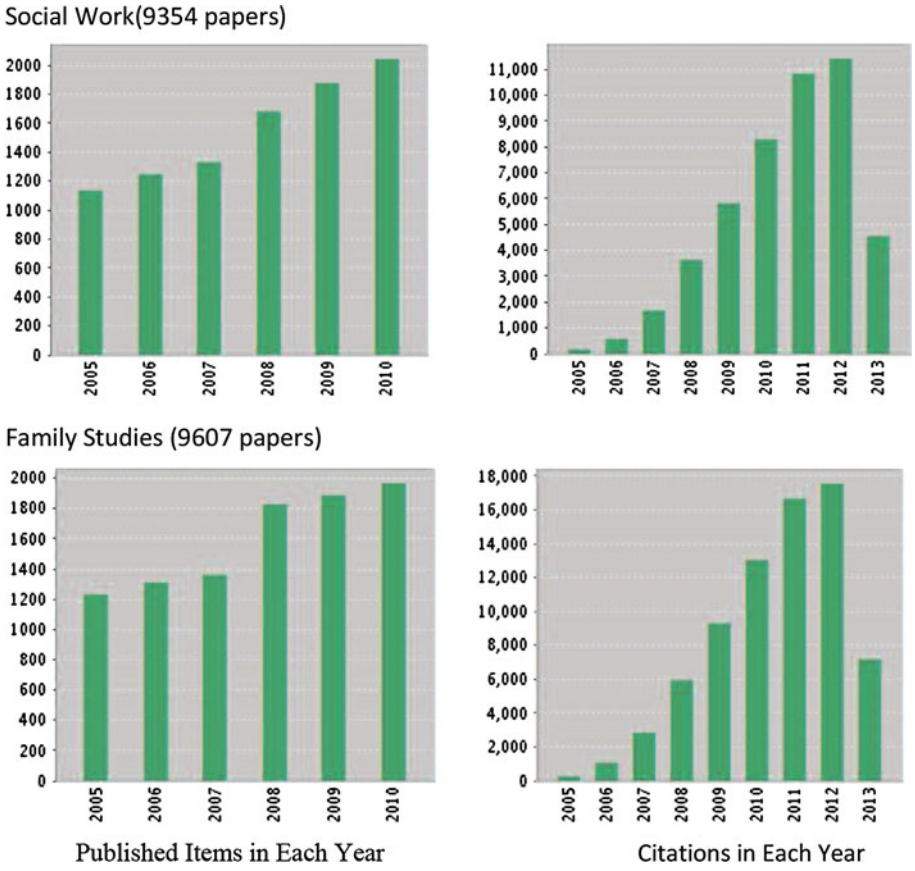

Fig. 1 "Social work" versus "family studies"

(Stack 2012), "Pain Medicine" (Li et al. 2012), "Plastic and Reconstructive Surgery" (Zhang et al. 2012), "Dentistry" (Feijoo et al. 2013), "Orthodontist" (Hui et al. 2013), "Respirology" (Tam et al. 2013), "Arthroscopy" (Cassar et al. 2012). Then, we simulate in WoS the same search process of each case with the same timespan. In Table 4 we show the search strategies followed in each discipline.

In Table 5 we show the results obtained by H-Classics in comparison with the results of T-Classics. In general, if we compare graphically the results of both as it is shown in Fig. 2, we can conclude that H-Classics provides us very different results to T-Classics. And in fact, the correlation coefficient between both is 0.45, which is a low correlation value. Consequently, we might think that both methods show us different views of the citation classics. This happens because in H-Classics we firstly set the citation rates or thresholds to be satisfied by the papers to be considered citations classics and then we identify the citation classics. This identification process is very different to the most of considered procedures of T-Classics that firstly set the specific number of papers that must appear as citation classics (case 4 to case 9) attending to the traditional expert recommendations but not considering any citation criterion.

Except in the research area of "Orthodontist" (where T-Classics and H-Classics provide similar results, i.e., 100 and 98 citation classics), in other disciplines H-Classics always

Table 4 Search strategies

Discipline	Search strategy
Epilepsy	TS = (epilepsy or epilepsies or epileptic or epilepticus or seizures or seizure), timespan = 1900–2011
Parkinson	TS = (Parkinson), timespan = 1900–2010
Suicidology	SO = (Suicide and Life Threatening Behavior), timespan = 1900–2011
Pain Med.	SU = (Anesthesiology) or so = ((Journal of Pain) or (Molecular Pain) or (Journal of Pain and Symptom Management) or (Pain Management Nursing) or (Pain Medicine) or (Journal of Headache and Pain) or (Journal of Musculoskeletal Pain) or (Journal of Orofacial Pain)), timespan = 1900–2010
Plastic and Rec. Surg.	SO = ((Plast Reconstr Surg) or (Arch Facial Plast S) or (J Plast Reconstr Aes) or (Ann Plas Surg) or (Aesthet Plast Surg) or (Clin Plast Surg) or (J Plast Film Sheet) or (Facial Plast Surg) or (Ophthal Plast Recons) or (Can J Plast Surg) or (J Plast Surg Hand Su)), timespan = 1900–2011
Dentistry	SU = (Dentistry, Oral Surgery & Medicine), timespan = 1900–2012
Orthodontist	SO = ((American Journal of Orthodontics and Dentofacial Orthopedics) or (The Angle Orthodontist) or (European Journal of Orthodontics)), timespan = 1900–2011
Respirology	SU = (Respiratory System), timespan = 1900–2011
Arthroscopy	TS = (Arthroscopy), timespan = 1900–2011

Table 5 T-Classics versus H-Classics

Discipline	#(T-Classics)	#(H-Classics)	#(Papers)
1. Epilepsy	89	323	99109
2. Parkinson	107	383	63471
3. Suicidology	12	58	1307
4. Pain Med.	100	271	106050
5. Plastic and Rec. Surg.	100	154	29439
6. Dentistry	100	246	181513
7. Orthodontist	100	98	8163
8. Respirology	50	358	185563
9. Arthroscopy	25	109	7680

gives us a greater number of citation classics. Therefore, H-Classics provides a more complete mapping of the classical literature of a research area than T-Classics. This happens because T-Classics searches the classical literature by setting or a very high citation rate of 400 citations received (as in "Epilepsy" and "Parkinson") or a very low specific number of citation classics as 100, 50 or 25 (as in "Dentistry", "Respirology" and "Arthroscopy", respectively).

On the other hand, if we compare the output of T-Classics and H-Classics with respect to the dimension of the each research area expressed in number of papers (#(*Papers*)), we obtain the following correlations coefficients, 0.27 and 0.72, respectively. Therefore, the weak correlation of T-Classics justifies the use of the H-Classics, which satisfactorily

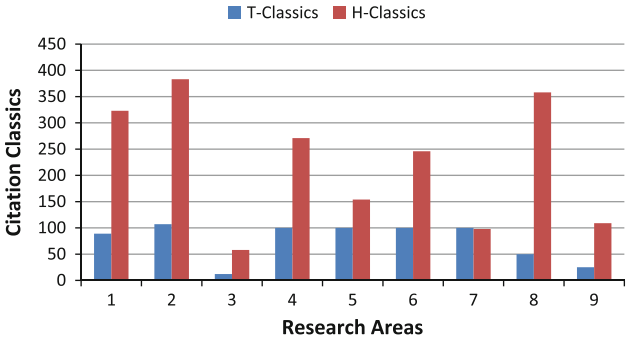

Fig. 2 T-Classics versus H-Classics

combines both traditional approaches to identify the citation classics and reflects better the dimension of the research area.

Concluding remarks

In this paper, we have presented a new concept to characterize the citation classics of a research area, the H-Classics, which is based on the popular and rigorous bibliometric criterion H-index. We have introduced it to overcome the problems detected in recent studies of citation classics developed in different disciplines. We have shown that H-Classics is sensitive to the own citation practices of any research discipline and also its evolution. It is an unbiased and fair criterion to systematize search procedure of citation classics for any research area. Furthermore, we have shown some good properties of H-Classics by means of examples of studies of citation classics published yet.

We should point out that the H-Classics of a scientific category are a valuable information source to develop data analysis in a scientific discipline. In fact, H-Classics can help researchers who want to start their work in a discipline, for example, giving them to know the most important topics and authors who lead these topics. Additionally, H-Classics can enrich other bibliometric analysis that can be developed with other techniques like science mapping (Cobo et al. 2012).

Finally, we should point out the good behaviour of the H-Classics, which provides a more complete mapping of the classical literature than other studies analyzed.

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