DE GRUYTER
OPEN

Research Paper

"Sparking" and "Igniting" Key Publications of 2020 Nobel Prize Laureates

Fangjie Xi[1], Ronald Rousseau[2,3], Xiaojun Hu[1,4†]

[1]Medical Information Center, Zhejiang University School of Medicine, Hangzhou 310058, China
[2]Faculty of Social Sciences, University of Antwerp, Middelheimlaan 2, 2020 Antwerpen, Belgium
[3]Centre for R&D Monitoring (ECOOM) and Dept. MSI, KU Leuven, Naamsestraat 61, 3000 Leuven, Belgium
[4]Department of Neurology of Affiliated Hospital 2, Zhejiang University School of Medicine, Hangzhou 310009, China

Citation: Xi, F.J., Rousseau, R., & Hu, X.J. (2021). "Sparking" and "igniting" key publications of 2020 Nobel Prize laureates. *Journal of Data and Information Science*, 6(2), 28–40. https://doi.org/10.2478/jdis-2021-0016

Received: Jan., 19, 2021
Accepted: Feb. 7, 2021

Abstract

Purpose: This article aims to determine the percentage of "Sparking" articles among the work of this year's Nobel Prize winners in medicine, physics, and chemistry.

Design/methodology/approach: We focus on under-cited influential research among the key publications as mentioned by the Nobel Prize Committee for the 2020 Noble Prize laureates. Specifically, we extracted data from the Web of Science, and calculated the Sparking Indices using the formulas as proposed by Hu and Rousseau in 2016 and 2017. In addition, we identified another type of igniting articles based on the notion in 2017.

Findings: In the fields of medicine and physics, the proportions of articles with sparking characteristics share 78.571% and 68.75% respectively, yet, in chemistry 90% articles characterized by "igniting". Moreover, the two types of articles share more than 93% in the work of the Nobel Prize included in this study.

Research limitations: Our research did not cover the impact of topic, socio-political, and author's reputation on the Sparking Indices.

Practical implications: Our study shows that the Sparking Indices truly reflect influence of the best research work, so it can be used to detect under-cited influential articles, as well as identifying fundamental work.

Originality/value: Our findings suggest that the Sparking Indices have good applicability for research evaluation.

Keywords Sparking Indices; Sparking fundamental research; Igniting fundamental research; Nobel Prize laureates; Under-cited influential research

† Corresponding author: Xiaojun Hu (E-mail: xjhu@zju.edu.cn).

1 Introduction

For 120 years the Nobel Prize is the most influential and prestigious international scientific award in the world. The work performed by Nobel Prize winners in physics, chemistry, and physiology or medicine (in short: medicine) usually had lead to profound changes in existing knowledge. Therefore, the identification of the main articles of Nobel Prize winners is particularly important. In this investigation, we focus on under-cited influential research (Hu & Rousseau, 2016) to determine the percentage of "Sparking" articles among the work of this year's Nobel Prize winners in the above mentioned fields.

Hu and Rousseau (2017) defined an igniting fundamental work as a publication that received a large number of citations as soon as it was published (a precise definition is given below). In other words, an igniting fundamental work can—virtually—ignite a huge flame of scientific research, easily visible through received citations.

A sparking fundamental work may not have numerous direct citations, but it has led to a series of important subsequent studies. Like a spark, although there is no brilliant flame at the beginning, it inspires (enlightens) follow up studies. Concretely, we defined an article of the sparking type if it meets the following three requirements.

1) The article is reasonably well-cited (a basic requirement to be influential);
2) The article receives fewer citations than expected;
3) Based on the two above conditions, second-generation citations are heavily cited, which shows that the original one has an important indirect impact.

Also these requirements are made precise further on.

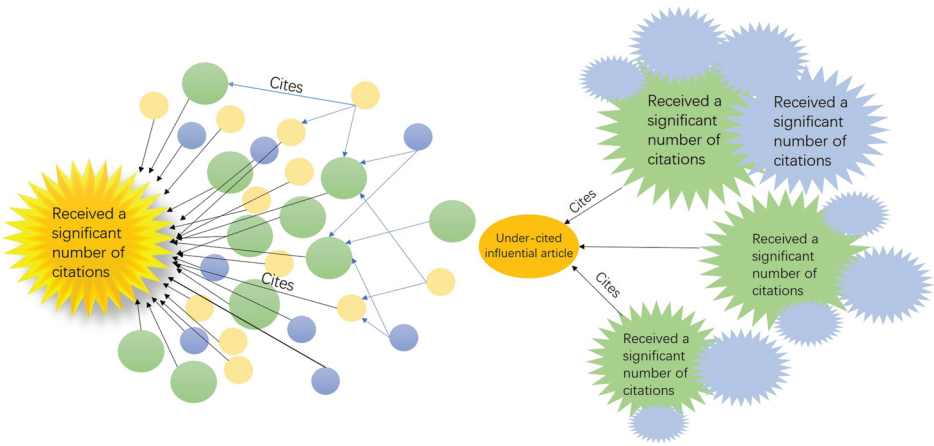

Figure 1. Different types of influences stemming from two kinds of fundamental work in a citation network.

2 Methodology

We determine under-cited influential work based on the *TOPCM* and *TTPCM* algorithms introduced in (Hu & Rousseau, 2016) and define the corresponding Sparking Indices. For the reader's convenience we include the methodology as published in (Hu & Rousseau, 2016, 2017).

The TOPCM algorithm and the Sparking Index S_1

Given an article A, its $TOPCM_3(A)$ value is obtained as:

$$TOPCM_3(A) = \frac{2}{3}\mu_1 + \frac{1}{3}\mu_2 \quad (1)$$

where $TOPCM_3$ stands for the Top 1% Citations Median of article A, including three—possibly overlapping—generations of citations. The symbol μ_1 stands for the median number of citations received by the top 1% citations of article A, reflecting the reaction in the second citation generation; μ_2 is the median of medians for the number of citations received by the second citation generation of the top 1% set (reflecting the reaction in the third citation generation). The whole procedure is illustrated and explained in detail in (Hu & Rousseau, 2016). The number $TOPCM_3(A)$ is defined as the Sparking Index on the 1% level of article A.

Article A is said to be an under-cited influential publication on the 1% level if its Sparking Index S_1 is higher than the top percentile most-cited articles (publications of article type) in the field, with same publication year as publication A and is higher than the number of direct citations received by publication A. To make sure that an under-cited influential article is itself cited a reasonable number of times it is required that it is cited more than 200 times. Such articles will be said to be sparking fundamental work (on the 1% level).

The TTPCM algorithm and the Sparking Index S_{10}

For somewhat less important work we introduced the Sparking Index S_{10} (Hu & Rousseau, 2016, 2017). Given an article A, its $TTPCM_3(A)$ value is obtained as:

$$TTPCM_3(A) = \frac{2}{3}\lambda_1 + \frac{1}{3}\lambda_2 \quad (2)$$

where $TTPCM_3$ stands for the Top 10% Citations Median of article A. The symbols λ_1 and λ_2 stand for the citation medians calculated from top 10% sets instead of top 1% sets. Similar to formula (1) the index 3 reflects the fact that three citation generations are involved. The number $TTPCM_3(A)$ is defined as the Sparking Index on the 10% level of article A.

Article A is said to be an under-cited influential publication on the 10% level if its Sparking Index S_{10} is higher than the top decile most-cited articles (publications of article type) in the field, with same publication year as publication A and is moreover higher than the number of direct citations received by publication A. For these articles we require that they are cited more than 20 times. Such articles will be said to be sparking fundamental work (on the 10% level).

Igniting fundamental work

If the direct citations of article A are larger than $S_1(A)$ and belong to the top 1% most cited articles published in the same year and in the same field, then we say that article A is an igniting fundamental article. Formally, we add the requirement that A received at least 200 citations, although in this publication this requirement is totally superfluous.

3 Data collection

Data for our investigations are the key publications as mentioned by the Nobel Prize Committee for the 2020 Noble Prize laureates in medicine, physics, and chemistry (https://www.nobelprize.org/).

3.1 Physiology or medicine: Harvey J. Alter, Michael Houghton, and Charles M. Rice

As announced by the Royal Swedish Academy of Sciences, the 2020 Nobel Prize in Medicine was won by Harvey J. Alter, Michael Houghton, and Charles M. Rice for the discovery of the hepatitis C virus. Among the key publications reported in the scientific background (RSAS, 2020a), there are 14 articles written by at least one of the three scholars. We will introduce the characteristics of these 14 articles in detail later.

Hepatitis A and B had long been identified before researchers were able to isolate and identify the hepatitis C virus. Moreover, it has taken many years before effective antiviral medicines became available, and even now challenges remain in the form of cost and access. Contrary to the case of hepatitis A and B, there is no vaccine against hepatitis C available. Because of these facts it is no surprise that recently more articles are published related to hepatitis C, than to hepatitis A or B (Sangam et al., 2018).

3.2 Physics: Roger Penrose, Reinhard Genzel, and Andrea Ghez

The Royal Swedish Academy of Sciences awarded the Nobel Prize in Physics 2020 to Roger Penrose, Reinhard Genzel, and Andrea Ghez, for establishing the

theoretical foundation of black holes and the detection of a supermassive compact object at the galactic center. Among the 54 publications of the official report (RSAS, 2020b), 19 papers were written by at least one of the three laureates above, among which, only 17 articles are of article type. Therefore, the final number of included articles in the field of physics is 17.

One of the main publications of Penrose was in collaboration with Stephen Hawking (Penrose & Hawking, 1970). Had he not died in 2018 he would have been a possible candidate for the 2020 Nobel Prize in physics.

3.3 Chemistry: Emmanuelle Charpentier and Jennifer A. Doudna

Emmanuelle Charpentier and Jennifer A. Doudna were awarded the Nobel Prize in Chemistry 2020 for the development of a method for genome editing. There is no doubt that gene editing has been a hot topic for more than ten years. The two authors' articles extracted from the scientific background were also published between 2011 and 2020 (RSAS, 2020c). We found that the key publications of the two laureates of the 2020 Nobel Prize in Chemistry were almost all heavily cited. They immediately ignited a huge research fire.

Because we focus on under-cited influential research, we will pay more attention to the fields of medicine and physics. We extracted data from the Web of Science including authors, titles, sources, and publication years, etc. (The latest search was done on October 29, 2020.). We then calculated the Sparking Indices using formulas (1) and (2).

Nobel Prize winners are often associated with delayed recognition (Campanario, 2009; Garfield, 1985; Gorry & Ragouet, 2019; Li & Shi, 2016) or with rejections of the first submission of their early publications (Campanario, 2009). We will not investigate these aspects in this publication. Yet, we note that Mojica (2005), a precursor of Charpentier and Doudna, who co-introduced (with Jansen) the name CRISPR, had serious problems to publish his work (Campbell, 2019). This also happened to Šikšnys, who at the same time as Charpentier and Doudna made similar observations as they did.

4 Results

4.1 Fundamental work by the 2020 Nobel Prize laureates in Medicine

The six articles shown in Table 1 have a relatively low number of direct citations, respectively 302, 298, 489, 327, 322, and 527. However, their Sparking Indices S_1 are relatively high, namely two to three times the number of direct citations. A typical example is the article of Alter published in *Lancet* 1975, whose Sparking Index S_1 is 2.9 times that of its direct citations. In this article, Alter proposed "non-A, non-B hepatitis (NANBH)" for what we call now hepatitis C (Alter et al., 1975).

Table 1. The top 1% Sparking Indices of the 2020 Nobel Prize winners in medicine.

First author	Contributing Nobel Prize winner	Source	PY	Times cited	μ_1	μ_2	S_1	#Top1% citations
Alter,HJ	Alter,HJ	Annals of Internal Medicine	1972	302	524	1,008	685	253
Alter,HJ	*Alter,HJ*	*Lancet*	*1975*	*298*	*904*	*818*	*875*	*256*
Feinstone,SM	Alter,HJ	New England Journal of Medicine	1975	489	1,060	779	966	256
Alter,HJ	Alter,HJ	Lancet	1978	327	621	809	683	211
Kolykhalov,AA	Rice,CM	Journal of Virology	1996	322	1,034	625	898	256
Kolykhalov,AA	Rice,CM	Science	1997	527	1,731	695	1,385	241

Figure 2 shows the citation network of the above article. It can be seen that the article published by Kuo et al. in 1989 received 2,999 citations, which shows that this work plays a very important role in the citation of future generations. In the same year, the article published by Choo et al. attracted greater attention and received 5,715 citations. These two examples above embody that Alter's article in 1975 stimulates the research boom indirectly in this field. We further observe that there are many co-citations in the citation network, which indicates that there is some correlation between citing publications.

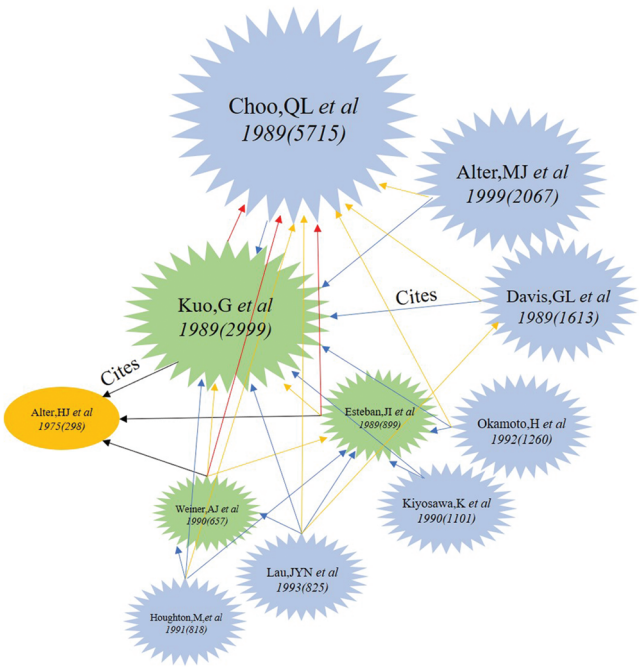

Figure 2. The top percentile most-cited articles and their significant follow-up researches that stem from Alter's 1975 paper (Clinical and serological analysis of transfusion-associated hepatitis. *Lancet*, 2(7940): 838–841.) (shown in part).

Research Paper

Sparking indices have been well confirmed in the fundamental work of the 2020 Nobel Prize in Medicine. Table 3 shows that among the 14 original articles of the 2020 Nobel Prize laureates in Medicine, 11 are under-cited influential papers according to our definition (Hu & Rousseau, 2016), so they are considered to be sparking fundamental work. In other words, about 79% of the original articles fall into the category of sparking fundamental work, while the remaining 21% fall into the category of igniting work.

Table 2. The top 10% Sparking Indices of the 2020 Nobel Prize winners in medicine.

First author	Contributing Nobel Prize winner	Source	PY	Times cited	λ_1	λ_2	S_{10}	#Top10% citations
Chalmers,TC	Alter,HJ	New England Journal of Medicine	1971	90	128	123	126	62
Alter,HJ	Alter,HJ	American Journal of the Medical Sciences	1975	69	117	200	145	53
Feinstone,SM	Alter,HJ	Infection and Immunity	1983	95	288	249	275	F1[a]:79 F2[a]:65
He,LF	Alter,HJ	Journal of Infectious Diseases	1987	118	399	260	352	F1[a]:81 F2:63 F3:70
Blight,KJ	Rice,CM	Journal of Virology	1997	145	218	221	219	100

[a]If the journal has published an article that belongs to more than one Web of Science category, we denote them F1, F2, or F3. In the case an article is published in a journal that belongs to the category "Multidisciplinary Science", we regard this article as belonging to the Web of Science category to which the "most cited" article belongs.

Table 3. Characteristics of the publications by the 2020 Nobel Prize winners in medicine.

First author	Contributing Nobel Prize Winner(s)	Source	PY	IF belongs to sparking fundamental work	IF belongs to igniting fundamental work
Alter,HJ	Alter,HJ	Annals of Internal Medicine	1972	Yes	
Alter,HJ	Alter,HJ	Lancet	1975	Yes	
Feinstone,SM	Alter,HJ	New England Journal of Medicine	1975	Yes	
Alter,HJ	Alter,HJ	Lancet	1978	Yes	
Chalmers,TC	Alter,HJ	New England Journal of Medicine	1971	Yes	
Alter,HJ	Alter,HJ	American Journal of the Medical Sciences	1975	Yes	
Feinstone,SM	Alter,HJ	Infection and Immunity	1983	Yes	
He,LF	Alter,HJ	Journal of Infectious Diseases	1987	Yes	
Blumberg,BS	Alter,HJ	Journal of the American Medical Association	1965		Yes
Kuo,G	Alter,HJ & Houghton,M	Science	1989		Yes
Kolykhalov,AA	Rice,CM	Journal of Virology	1996	Yes	
Kolykhalov,AA	Rice,CM	Science	1997	Yes	
Blight,KJ	Rice,CM	Journal of Virology	1997	Yes	
Choo,QL	Houghton,M	Science	1989		Yes
Percentage of Sparking work: 79%			**Percentage of Igniting work: 21%**		

4.2 Fundamental work by the 2020 Nobel Prize laureates in Physics

The top 1% Sparking indices of the articles by 2020 Nobel Prize laureates in physics are listed in Table 4. An article by Penrose published in *Nature-Physical Science* in 1971, received 186 direct citations, but its Sparking Index S_1 is 1,743, which is more than nine times the number of direct citations. It shows that the value of this article is seriously underestimated. Figure 3 shows the citation network of this article.

Table 4. The top 1% Sparking Indices of the 2020 Nobel Prize winners in physics.

First author	Contributing Nobel Prize winner	Source	PY	Times cited	μ_1	μ_2	S_1	#Top1% citations
Penrose,R	Penrose,R	Physical Review Letters	1963	362	711	1,159	860	435
Penrose,R	Penrose,R	Physical Review Letters	1965	995	1,135	744	1,005	312
Penrose,R	*Penrose,R*	*Nature-Physical Science*	*1971*	*186*	*2,174*	*881*	*1,743*	*244*
Eckart,A	Genzel,R	Nature	1996	263	978	943	966	340
Eckart,A	Genzel,R	Monthly Notices of the Royal Astronomical Society	1997	300	1,027	675	910	304
Schodel,R	Genzel,R	Nature	2002	626	1,087	609	928	332
Genzel,R	Genzel,R	Nature	2003	451	557	391	502	340
Gillessen,S	Genzel,R	Astrophysical Journal Letters	2009	254	687	278	551	247
Ghez,A.M	Ghez,A.M	Astrophysical Journal	1998	454	1,980	594	1,518	363
Ghez,A.M	Ghez,A.M	Astrophysical Journal	2003	412	924	609	819	340

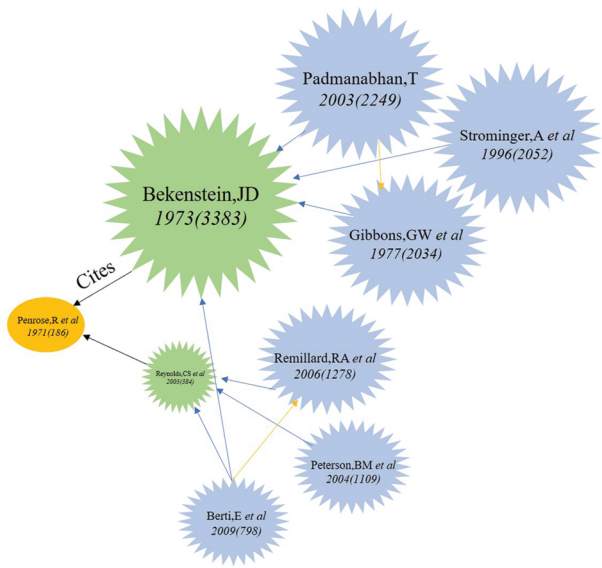

Figure 3. The top percentile most-cited articles and their significant follow-up research that stem from Penrose's 1971 paper (Extraction of rotational energy from a black hole. *Nature Physical Science*, 229(6): 177–179) (shown in part).

As shown in Table 6, a total of 17 original literature have been collected in the field of Nobel Prize in Physics, among which 11 articles belong to the type of sparking fundamental work, sharing 68.75%, and 4 articles belong to the type of igniting fundamental work, accounting for 25%.

Table 5. The top 10% Sparking Indices of the 2020 Nobel Prize winners in physics.

First author	Contributing Nobel Prize winner	Source	PY	Times cited	λ_1	λ_2	S_{10}	#Top10% citations
Abuter, R	Genzel,R	Astronomy and Astrophysics	2018	34	57.5	14.5	43.2	19

Table 6. Characteristics of the publications by the 2020 Nobel Prize winners in physics.

First author	Contributing Nobel Prize winner	Source	PY	IF belongs to sparking fundamental work	IF belongs to igniting fundamental work
Penrose,R	Penrose,R	Physical Review Letters	1963	Yes	
Penrose,R	Penrose,R	Physical Review Letters	1965	Yes	
Penrose,R	Penrose,R	Nuovo Cimento Rivista Serie[b]	1969	/	/
Hawking,S.W	Penrose,R	Proceedings of the Royal Society of London Series A	1970		Yes
Penrose,R	Penrose,R	Nature-Physical Science	1971	Yes	
Eckart,A	Genzel,R	Nature	1996	Yes	
Eckart,A	Genzel,R	Monthly Notices of the Royal Astronomical Society	1997	Yes	
Schodel,R	Genzel,R	Nature	2002	Yes	
Genzel,R	Genzel,R	Nature	2003	Yes	
Gillessen,S	Genzel,R	Astrophysical Journal	2009		Yes
Gillessen,S	Genzel,R	Astrophysical Journal Letters	2009	Yes	
Genzel,R	Genzel,R	Reviews of Modern Physic	2010		Yes
Abuter,R	Genzel,R	Astronomy and Astrophysics	2018	Yes	
Ghez,A.M	Ghez,A.M	Astrophysical Journal	1998	Yes	
Wizinowich,P	Ghez,A.M	Publications of The Astronomical Society of the Pacific	2000	No	No
Ghez,A.M	Ghez,A.M	Astrophysical Journal	2003	Yes	
Ghez,A.M	Ghez,A.M	Astrophysical Journal	2008		Yes
Percentage of Sparking work: 68.75%			**Percentage of Igniting work: 25%**		

[b] The journal Nuovo Cimento Rivista Serie was not included in WoS until the year 1976.

4.3 Fundamental work by the 2020 Nobel Prize laureates in Chemistry

Unlike the fields of medicine and physics, which refer to somewhat older publications, the Nobel Prize winning articles in chemistry are published between 2011 and 2020. This phenomenon occurs partly because DNA as an important piece of genetic information was only detected in 1944 (ref), and its structure fully understood in 1953 (Watson & Crick, 1953), based on crucial information by Franklin and Gossling (1953). Then the genetic code was deciphered in 1966. All

this was mainly based on the study of archaea, bacteria and viruses. In 1987 Ishino (Ishino et al., 1987) discovered the DNA sequence that would later be called CRISPR. The term CRISPR, short for clustered regularly interspaced short palindromic repeats, was not defined before 2002 (Campbell, 2019; Jansen et al., 2002), and then, finally in 2012 the CRISPPR-Cas9 technique was introduced by Charpentier and Dudna (2012), immediately (or even concurrently) leading to other fundamental work by Šikšnys, Zhang, Church, and others.

Table 7. The top 1% Sparking Indices of the 2020 Nobel Prize winners in chemistry.

First author	Contributing Nobel Prize winner	Source	PY	Times cited	μ_1	μ_2	S_1	#Top1% citations
Jiang,FG	*Charpentier,E*	*Science*	*2015*	*224*	*1032*	*374*	*812.6667*	*151*

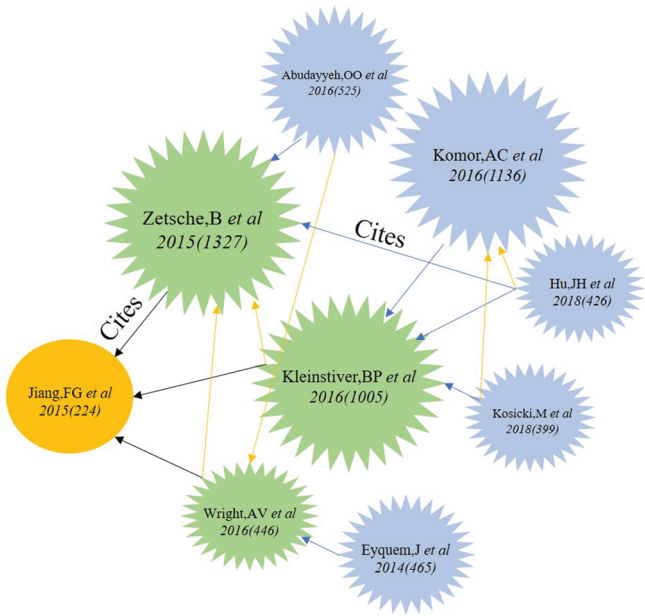

Figure 4. The top percentile most-cited articles and their significant follow-up research stemming from Charpentier's 2015 paper (A Cas9-guide RNA complex preorganized for target DNA recognition. *Science*, 348(6242): 1477–1481.) (shown in part).

It can be seen from Table 8 that among the ten articles of this year's Nobel Prize laureates in chemistry, nine articles are igniting fundamental work, accounting for up to 90% of the total, indicating that gene-editing technology is indeed a hot topic in recent years. Scholars also pay more attention to achievements in this field. The last remaining work is the article published by Jiang et al. in *Science* in 2015, which

is a sparking fundamental work. But it may also turn into an igniting fundamental work with an increase in the number of direct citations because of the influence of the Nobel Prize. We note that in our previous work (Hu & Rousseau, 2016) we included (Deltcheva et al., 2011) as a sparking publication, but meanwhile it has become an igniting one, deserving mention by the Nobel Prize Committee.

Table 8. Characteristics of the publications by the 2020 Nobel Prize winners in chemistry.

First author	Contributing Nobel Prize Winner(s)	Source	PY	IF belongs to sparking fundamental work	IF belongs to igniting fundamental work
Deltcheva,E	Charpentier,E	Nature	2011		Yes
Jinek,M	Charpentier,E&Doudna,J.A	Nature	2011		Yes
Pattanayak,V	Doudna,J.A	Nature Biotechnology	2013		Yes
Jinek,M	Charpentier,E&Doudna,J.A	Science	2014		Yes
Sternberg,SH	Doudna,J.A	Nature	2014		Yes
Jiang,FG	Doudna,J.A	Science	2015	Yes	
Jiang,FG	Doudna,J.A	Annual Review of Biophysics	2017		Yes
Knott,GJ	Doudna,J.A	Science	2018		Yes
Hille,F	Charpentier,E	Cell	2018		Yes
Makarova,KS	Charpentier,E	Nature Reviews Microbiology	2020		Yes
Percentage of Sparking work: 10%		**Percentage of Igniting work: 90%**			

5 Conclusions

5.1 The high rate of sparking and igniting articles in Nobel Prize winning articles

By analyzing the citation history of articles of Nobel Prize laureates in 2020, we found that, if they are not "igniting" (immediate recognition by citations) they can certainly by described as sparking. This proves that the Sparking Indices truly reflect influence of the best research work. In the fields of medicine and physics, more than 68% of the articles cited by the Nobel prize Committee belongs to the group of sparking publications.

5.2 Implications for research evaluation

The evidence provided by our investigation suggests that Sparking Indices can be used to detect under-cited influential articles, as well as assessing fundamental work. For example, the Sparking Indices can be used as evaluation criteria for promotions, hirings, Nobel Prize winner predictions, and funding decisions.

We finally note that several factors can potentially affect the size of Sparking Indices over time, such as the topic, the publication year, the reputation of its

authors, socio-political factors such as local conflicts, and so on. Further work is necessary to analyze Sparking type work in different fields and to study their possible influence on the reputation of its authors.

Acknowledgments

This work was supported by the National Natural Science Foundation of China Grant numbers: 71974167 and 71573225.

Author contributions

Fangjie Xi (22018070@zju.edu.cn): data collection, data processing, writing the manuscript. Ronald Rousseau (ronald.rousseau@uantwerpen.be): research question proposal, writing the manuscript. Xiaojun Hu(xjhu@zju.edu.cn): initiated the idea, research question proposal, the design of methodology, writing the manuscript.

References

Alter, H.J., Holland, P.V., Morrow, A.G., Purcell, R.H., Feinstone, S.M., & Moritsugu Y. (1975). Clinical and serological analysis of transfusion-associated hepatitis. Lancet, 2(7940), 838–841. doi:10.1016/S0140-6736(75)90234-2.

Campanario, J.M. (2009). Rejecting and resisting Nobel class discoveries: Accounts by Nobel Laureates. Scientometrics, 81(2), 549–565. doi:10.1007/s11192-008-2141-5.

Campbell, M. (2019). Francis Mojica: The modest microbiologist who discovered and named CRISPR. https://www.technologynetworks.com/genomics/articles/francis-mojica-the-modest-microbiologist-who-discovered-and-named-crispr-325093

Deltcheva, E., Chylinski, K., Sharma, C.M., Gonzales, K., Chao, Y.J., Pirzada, Z.A., . . . , & Charpentier, E. (2011). CRISPR RNA maturation by trans-encoded small RNA and host factor RNase III. Nature, 471(7340), 602–607. doi:10.1038/nature09886.

Garfield, E. (1986). The 1985 Nobel Chemistry Prize to Jerome Karle and Herbert A. Hauptman and the Physics Prize to Klaus von Klitzing contrast delayed versus "instant" recognition. Current Contents (November 3). Reprinted in Essays of an Information Scientist, 9, 336.

Gorry, P., & Ragouet, P. (2019). Eponomy and delayed recognition: The case of Otto Warburg Nobel Prize. In: 17th International Conference on Scientometrics & Informetrics. Proceedings (Catalano, Daraio, Gregori, Moed & Ruocco, Eds.) (pp. 2183–2188). Rome: Efesto.

Hu, X.J., & Rousseau, R. (2016). Scientific influence is not always visible: The phenomenon of under-cited influential publications. Journal of Informetrics, 10(4), 1079–1091. doi:10.1016/j.joi.2016.10.002.

Hu, X.J., & Rousseau, R. (2017). Nobel Prize Winners 2016: Igniting or sparking foundational publications? Scientometrics, 110(1), 1053–1063. doi:10.1007/s11192-016-2205-x.

Ishino, Y., Shinagawa, H., Makino, K., Amemura, M., & Nakata, A. (1987). Nucleotide sequence of the iap gene, responsible for alkaline phosphatase isozyme conversion in Escherichia coli, and identification of the gene product. Journal of Bacteriology, 169(12), 5429–5433. doi:10.1128/jb.169.12.5429-5433.1987.

Jansen, R., van Embden, J.D.A., Gaastra, W., & Schouls, L.M. (2002). Identification of genes that are associated with DNA repeats in prokaryotes.Molecular Microbiology, 43(6), 1565–1575. doi:10.1046/j.1365-2958.2002.02839.x.

Li, J., & Shi, D.B. (2016). Sleeping beauties in genius work: When were they awakened? Journal of the Association for Information Science and Technology, 67(2), 432–440.doi: 10.1002/asi.23380.

Mojica, F.J.M., Díez-Villaseñor, C., García-Martínez, J., & Soria, E. (2005). Intervening sequences of regularly spaced prokaryotic repeats derive from foreign genetic elements. Journal of Molecular Evolution, 60(2), 174–182. doi: 10.1007/s00239-004-0046-3.

RSAS (The Royal Swedish Academy of Sciences). (2020a). Scientific background the discovery of Hepatitis C. https://www.nobelprize.org/uploads/2020/10/advanced-medicineprize2020-2.pdf

RSAS (The Royal Swedish Academy of Sciences). (2020b). Scientific Background on the Nobel Prize in Physics 2020—Theoretical foundation for black holes and the supermassive compact object at the galactic centre. https://www.nobelprize.org/uploads/2020/10/advanced-physics prize2020.pdf

RSAS (The Royal Swedish Academy of Sciences). (2020c). Scientific Background on the Nobel Prize in Chemistry 2020—A tool for genome editing. https://www.nobelprize.org/uploads/2020/10/advanced-chemistryprize2020.pdf

Sangam, S. L., Arali, U.B., Patil, C.G., & Rousseau, R. (2018). Growth of the hepatitis literature over the period 1976–2015: What can the relative priority index teach us? Scientometrics, 115(1), 351–368. doi: 10.1007/s11192-018-2668-z.

van Raan, A.F.J.(2004). Sleeping Beauties in science. Scientometrics, 59(3), 467–472. doi:10.1023/B:SCIE.0000018543.82441.f1.

Watson, J.D., & Crick, F.H.C. (1953). Molecular structure of nucleic acids—a structure for deoxyribose nucleic acid. Nature, 171(4356), 737–738. doi:10.1038/171737a0.